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Royal Society of New Zealand

TRANSACTIONS

AND

PROCEEDINGS

of the Royal Society of New Zealand

OF THE

NEW ZEALAND INSTITUTE

1903

VOL. XXXVI.

(NINETEENTH OF NEW SERIES)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

A. HAMILTON

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NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867"; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER "THE NEW ZEALAND INSTITUTE ACT, 1903."

Board of Governors.

EX OFFICIO.

His Excellency the Governor.
The Hon. the Colonial Secretary.

NOMINATED BY THE GOVERNMENT UNDER CLAUSE 4.

Sir James Hector, K.C.M.G., M.D., F.R.S.; E. Tregear, F.R.G.S.; John Young; J. W. Joynt, M.A.

ELECTED BY AFFILIATED SOCIETIES UNDER CLAUSE 4.

Wellington: Martin Chapman; Professor T. H. Easterfield, M.A., Ph.D. Auckland: Professor A. P. W. Thomas, M.A., F.L.S.; J. Stewart, C.E. Napier: H. Hill, F.G.S. Christchurch: Professor Charles Chilton, D.Sc., F.L.S.; Captain F. W. Hutton, F.R.S. Westland: T. H. Gill, M.A. Nelson: L. Cockayne, LL.D. Otago: A. Hamilton; G. M. Thompson, F.L.S.

OFFICERS FOR THE YEAR 1903–4.

President: Captain F. W. Hutton, F.R.S.

Hon. Treasurer: J. W. Joynt, M.A.

Editor of Transactions: A. Hamilton.

Secretary: T. H. Gill, M.A.

AFFILIATED SOCIETIES.	DATE OF AFFILIATION.
Wellington Philosophical Society ...	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd October, 1868.
Otago Institute	18th October, 1869.
Westland Institute	21st December, 1874.
Hawke's Bay Philosophical Institute	31st March, 1875.
Southland Institute	21st July, 1880.
Nelson Institute	20th December, 1883.

NEW ZEALAND INSTITUTE ACT.

The following Act reconstituting the Institute was passed by Parliament :—

1903, No. 48.

An Act to reconstitute the New Zealand Institute.

[*18th November, 1903.*

Whereas it is desirable to reconstitute the New Zealand Institute with a view to connecting it more closely with the affiliated institutions :

Be it therefore enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. The Short Title of this Act is "The New Zealand Institute Act, 1903."

2. "The New Zealand Institute Act, 1867," is hereby repealed.

3. (1.) The body hitherto known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as may hereafter be incorporated in accordance with regulations to be made by the Board of Governors as hereinafter mentioned.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

4. The control and management of the Institute shall be in the hands of a Board of Governors, constituted as follows :—

The Governor ;

The Colonial Secretary ;

Four members to be appointed by the Governor in Council during the month of December, one thousand nine hundred and three, and two members to be similarly appointed during the month of December in every succeeding year ;

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year ;

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year.

5. (1.) Of the members appointed by the Governor in Council two shall retire annually on the appointment of their successors; the first two members to retire shall be decided by lot, and thereafter the two members longest in office without reappointment shall retire.

(2.) Subject to the provisions of the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

6. The Board of Governors as above constituted shall be a body corporate, by the name of the "New Zealand Institute," and by that name they shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

7. (1.) The Board of Governors shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) It shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) It shall have power to make regulations under which societies may become incorporated to the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with, and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property hereinafter vested in it, and of any additions hereafter made thereto, and shall make regulations for the management of the same, for the encouragement of research by the members of the Institute, and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

8. Any casual vacancy on the Board of Governors, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board of Governors.

9. (1.) The first annual meeting of the Board of Governors hereinbefore constituted shall be held at Wellington on some day in the month of January, one thousand nine hundred and four, to be fixed by the Governor, and annual meetings of the Board shall be regularly held thereafter during the month

of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board of Governors may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

10. The Board of Governors may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in the colony by any means that may appear desirable.

11. The Colonial Treasurer shall, without further appropriation than this Act, pay to the Board of Governors the annual sum of five hundred pounds, to be applied in or towards payment of the general current expenses of the Institute.

12. (1.) On the appointment of the first Board of Governors under this Act the Board of Governors constituted under the Act hereby repealed shall cease to exist, and the property then vested in, or belonging to, or under the control of that Board shall be vested in His Majesty for the use and benefit of the public.

(2.) On the recommendation of the President of the Institute the Governor may at any time hereinafter, by Order in Council, declare that any part of such property specified in the Order shall be vested in the Board constituted under this Act.

13. All regulations, together with a copy of the Transactions of the Institute, shall be laid upon the table of both Houses of Parliament within twenty days after the meeting thereof.

REGULATIONS.

The following are the new regulations of the New Zealand Institute under the Act of 1903 :—

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by "The New Zealand Institute Act, 1903."

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1903," unless such society shall consist of not less than

twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications :—

Regulations regarding Publications.

(*a*.) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b*.) The Board of Governors shall determine what papers are to be published.

(*c*.) Papers not recommended for publication may be returned to their authors if so desired.

(*d*.) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

General Regulations.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1903," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

9. In voting on any subject the President is to have a deliberate as well as a casting vote.

Management of the Property of the Institute.

10. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt, and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

11. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

12. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

13. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election

as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE, 1903.

I.—MISCELLANEOUS.

Art. I.—*Notes on Two Maori Calabashes, with Carved Wooden Necks called* Tuki *or* Ko-ano-ano.

By A. K. Newman.

[*Read before the Wellington Philosophical Society, 4th November, 1903.*]

Plates I. and II.

The Maoris having abandoned their original arts, and their old methods of fashioning weapons and utensils, and their charming quaint carvings, it is desirable that real original relics of all kinds should be described and depicted ere they become lost; and this is all the more necessary as the country is being flooded with cheap untrustworthy imitations. Originally the Maoris devoted much labour to carving ornaments, and such carvings abounded in the pas, but through time and neglect many of the commonest have become rare.

Recently I bought these two large calabashes, with their artistically carved wooden necks or mouthpieces, and as I cannot find any detailed account of them in our literature or in the Transactions I put on record this description, their history, and their uses. My pair were discovered lying neglected in a Maori outhouse in the Wairarapa. They belonged to a Maori who said they belonged to his grandfather, and are believed to be a hundred years old. This is probably true, for the making of such articles has long been abandoned, and the few now existing show marked signs of age.

Each calabash consists of the rind of a gourd called *hue*, the seed-vessel of a plant brought in the canoes from Hawaiki. To the neck of each gourd is affixed, at its narrowest part, a wooden collar or mouthpiece quaintly carved. The whole is called a *taha;* the neck is commonly known as *tuki*,

or, rarely, *ko-ano-ano*. The whole was surrounded by a network of flax, a sort of large open knotted network with the various ends twisted together to form a handle. This flax-work was called *kete*.

The Maoris, having no knowledge of pottery, ingeniously used these gourds to preserve the flesh of birds for eating. Pigeons were plucked and dressed and then put into the gourd, and the melted fat of the pigeons was then poured into it until full to the neck, which was finally covered by the broad leaves of the rangiora plant. Elsdon Best says the gourd had often a wooden lid, but I have never seen one in any museum. Sometimes the calabashes were clothed in closely woven flax covers, and some were planted on three elaborately carved legs. The meat so preserved was known as *huahua*. When pigeons were scarce tuis or wekas were made into *huahua*. Rats were thus preserved—always with their skins on. In the old cannibal days they were occasionally filled with choice bits of human flesh.

At Toka-anu I first saw a pair of *tukis*. They were shown to me by their owner, a great *rangatira*, and were among his choicest possessions, and clearly he was extremely proud of them. They were jet-black, and smaller than mine; in fact, the entrance was so narrow that former ancestors of his used to call up a small boy whose hand used to fish out the dainties. Best says that in consequence they were sometimes called *ngutu-iti*. Best has seen them ornamented with feathers. These *tahas* belonged to the chiefs, and at great feasts they acted as choice centre ornaments.

One of our greatest Maori authorities says they were formerly common in the Urewera country, and were rarer about Taupo. As far as I can discover they were rarely seen south of this. They are now rare. Three or four specimens are in the Auckland Museum, and there is one in the Maori house of the Wellington Museum. I have seen no others except the pair at Toka-anu and my pair, and *tukis* are absent from many collections. Mair has seen them weighing 100 lb. when full. Mair told me that none are now being made—kerosene-tins do as well and are less trouble to get. Hamilton in his great work on Maori art figures one, but has only a brief reference to it. His pair of calabashes in the museum are *minus* the *tukis*.

Neither Tregear nor Williams in their dictionaries have the word, but Tregear gives a Mangarevan word *putuki*, "to draw together the mouth of a sack." These *tukis* certainly draw together the necks of the calabashes, enclosing their meaty contents, which, in addition to the dainties above mentioned, sometimes were filled with dog-meat, of which Best says the hind quarters were most highly esteemed. On

rare occasions these calabashes were filled with fat worms. The Maoris were, therefore, well up in the art of preserving animal food in enclosed vessels, the interstices being filled with melted tallow.

It will be seen how rich is the mahogany red-brown colouring of these gourds, a result partly due to age and partly to the animal oil with which they were smeared inside and out. The Maoris now rarely grow these gourds, and the old people say that for some unknown reason they cannot grow them the same size as formerly. Mair has seen the gourds so large as to fill the two arms of any Native carrying them. My largest gourd is 46 in. in circumference, and its height from base to where the *tuki* is affixed is 13 in.

From the fact that I have seen only five specimens, all told, of these *tukis*, that there are three or four in the Auckland Museum and none here, I think I am justified in saying they are so rare now that they deserve fuller description, and to be embalmed in the pages of these Transactions.

These *tukis*, Mair tells me, were always made of the same wood, matai. Their degree of blackness depends partly upon their age and partly upon the amount of fat, and dirt, and smoke to which they have been submitted. Each *tuki*, being made of thick and hard wood, would outlast several generations of gourds, which were thin and brittle. The *tuki* was attached to the gourd by holes pierced at its lower end, through which flax was passed and then drawn through similar holes in the gourd. Each gourd near its narrow end was carefully pared down until it closely fitted the end of the *tuki*. The flax was then tightly tied, and the result was a very creditable piece of close-fitting workmanship. Outside, to cover the junction of the *tuki* and gourd, a broad strip of flax was very tightly tied. When the melted fat was poured in it filled all the crevices, and the *huahua* inside was preserved in an airtight chamber.

The Maoris used to preserve birds also in calabashes slit up in a different manner, of which pictures may be seen in White's "History of the Maori." They were frequently covered with a fine carving, necessarily very shallow owing to the thinness of the gourd. They were called *papa*, or *kumete*. White, though depicting with great care several specimens of *papa*, or *kumete*, does not depict a single specimen of a *taha* with a carved *tuki*. Moreover, the carving on a *papa* was radically different from that of a *tuki*.

The gourd of the larger *taha* is a rich mahogany red-brown, whilst the *tuki* is darker. The gourd is surrounded by flax knotted so as to form large diagonal four-sided figures surrounding the gourd and gathering together to be formed into a handle, thus making it easy to carry. It is quite likely

that the *tuki* is far older than the gourd. The smaller gourd was broken by being dropped whilst being carried on horseback, but the *tuki* is uninjured. Both *tukis* are made of matai. The *tuki*, or neck, of the larger calabash is 3 in. from top to bottom where it joins the gourd. Its circumference low down is 15 in. It is slightly bell-mouthed—it is $4\frac{3}{4}$ in. across the mouth, and is larger than most *tukis*. The other *tuki* is the same in shape and make, but it is smaller and is attached to a smaller gourd. The interior of each is quite smooth, and at the bottom it is pierced by several holes to fix it to the gourd. The carving of the larger *tuki* is in whorls, like much of the tattooing on a Maori's face, these whorls running round the *tuki*. The carving is beautifully done in parallel curving lines in groups of three, with between each group a series of small pinnacles arranged symmetrically between each band of three continuous lines. To break up the monotony, at two points opposite each other there are fresh lines running from top to bottom of the collar at right angles to each other. The rim is smooth on top, but its circumference is broken up by pairs of notches close together, but each pair equidistant from the others. The outside edge, which was originally a circle, has been pared down until it has become a seven-sided figure; the smaller *tuki* is similarly made into a fourteen-sided figure, but in each case only on the extreme outside edge of the rim. The *tukis* were always made circular. The smaller *tuki* is not notched in the rim, and the spiral curves wind uninterruptedly around the body.

These *tukis* seem to be excellent samples of Maori carving carried to its highest point. The gourds, with their rich red-brown colouring, surmounted by these exquisitely carved solid wooden necks, form really beautiful specimens of Maori art, and it is no wonder they were highly prized ornaments at big feasts.

Art. II. — *On the Maori Method of preparing and using* Kokowai.

By Archdeacon Walsh.

[*Read before the Auckland Institute, 3rd August, 1903.*]

I have much pleasure in presenting the Auckland Museum with a stone grinding-slab and rubber used by the Maoris of old time in the manufacture of their favourite red pigment generally known as *kokowai*.

The occasion seems to furnish an opportunity for offering a few notes on the subject, in the composition of which I

have had some difficulty, as in my residence in a country district I have not the means of consulting many works of reference. They are therefore not as complete as they might be under more favourable circumstances. I am largely indebted, however, to a compilation from various sources given in Hamilton's "Maori Art" (pp. 299–301), and have gathered a good deal of useful information from some of the older settlers in these parts, chiefly from Mr. James Bedggood, of Kerikeri, whose long residence among the natives and frequent opportunities of observation enable him to speak with authority on the subject.

The old Maoris' assortment of pigments was very limited. They used black and white, the former manufactured chiefly, I believe, from the soot of burned kauri-gum or resinous wood, and the latter from a kind of pipeclay. They had also a very beautiful cobalt blue called *pukepoto*, a natural product formed from the decomposition of fossil bones, and found in very limited quantities in pockets in clay rock. These, with the red *kokowai*, constituted the "palette" of the old-time Maoris. No attempt apparently was ever made to produce a variety of shades by the blending of the different colours.

Of the pigments named the *kokowai* was by far the most important. The black and the white were chiefly employed in small quantities for fine work, while the use of the blue was solely confined to personal adornment. But the *kokowai* was in universal requisition. It formed the general colour of all the painted work on the canoes, the houses, and the more ornamental portions of the palisading surrounding the pas; and it was also extensively used as a personal decoration, it being the very general custom of the chiefs and other people of note to cover their bodies with it.

The raw material from which this favourite pigment was made consisted of a species of red ochre or oxide of iron found in deposits in the ground. This was first roasted in a very hot *haangi*, or native oven, and afterwards ground to a fine powder on a flat stone by means of a round smooth boulder. A finer variety was produced from creeks and streams which held the oxide in suspension. Fascines of fern, &c., were sunk in the water, and after some time were found to be covered with a deposit of the material in the form of an impalpable powder. They were then taken out and dried, when the powder was easily shaken off, the result being a pigment of the very finest quality, which was made up into balls, wrapped in leaves, and roasted, as already described. This variety was called *horu*, that procured from deposits in the earth being known as *takou* (A. H. M., vol. iv., p. 103).

The vehicle generally used for the manufacture of the

paint was shark-oil, but when required for personal adornment it was often mixed with vegetable oils expressed from the seeds of the titoki (*Alectryon*), the kohia (*Passiflora*), the miro (*Podocarpus ferruginea*), or the tangiao (*Tetranthera calycaris*), which were more or less sweet-scented ("Maori Art," p. 300).

A convenient vessel for mixing the paint was found in the paua-shell (*Haliotis*). The small holes in these were stopped with a flax cord inserted in them and joined so as to form a handle ("Maori Art," p. 300). When required in a greater quantity a large vessel such as a calabash was employed.

Various modes were adopted in the application of the *kokowai*, each depending on the purpose for which it was required. For the treating of woodwork the mixture was made up into the consistency of ordinary paint and smeared over and rubbed in with a bunch of *muka*, or flax-fibre. When required for a cosmetic it was used in a more liquid state. Polack, in describing a *hahunga*, or feast at the ceremonial scraping of the bones of a chief, says, "Red paint was much in requisition. A quantity of the mixture was arranged in a broken calabash, into which some of these antipodal exquisites absolutely dipped the entire head and face" ("Manners and Customs of the New-Zealanders," vol. i., p. 81). In this form it was also used for saturating the clothes, which was sometimes done. Occasionally it was used in a form of greater consistency. One of the old writers relates that a Maori who was completely covered with *kokowai* kept a small lump of it in his hand, which he was constantly rubbing on to any portion of his body from which the colour had worn off.

Fortunately, the raw material for this much-sought-for pigment was pretty widely distributed; but as there was much difference in quality a good deposit of *kokowai* formed a valuable possession, and the question of ownership sometimes gave rise to tribal disputes. One important *kokowai*-field which supplied the wants of the people over a large portion of the Bay of Islands district is situated at a place called Te Ngau Areha, on the highest point of a range of hills which forms the watershed of the Waitangi and Waihou Rivers. Here are still to be seen several extensive excavations, each of which was under separate ownership, and of which one was always kept *tapu*, its product being reserved for sacred purposes. A similar field lies on the right bank of the Mangonui River, near the harbour, and probably many others now forgotten might be found in several places. Mr. Elsdon Best gives the name of a famous spring which deposited the red pigment near Ohaua. It was known as Nga Toto o Tawera (the Blood of the Morning Star). In Hawke's Bay four varieties are recognised—*kokowai*, *taupo*, *tareha*, and *taramea*. In Taranaki the material does not seem to be so

plentiful. Mr. W. H. Skinner, of the Survey Office, New Plymouth, informs me that the great place for the *kokowai*-deposits in the middle of that province is towards the head-waters of the Waiwakaiho River, among the spurs of Mount Egmont and the Patua Ranges. He also describes a place in the Mokau district where the work of collection was one of considerable difficulty and even danger. At the north side of the mouth of the river, he says, there are two or three caves worn out by the action of the sea. The floors of these caves are covered to a good depth by water, and away in their innermost recesses the deposits of *kokowai* are found. To obtain this the Maoris were obliged to swim, and in one place to dive under a depression of the roof, coming out in an inner chamber where the deposits lie. This field has long since been abandoned, and twenty years ago when Mr. Skinner visited the spot only one old Maori knew the secret of diving under the rock. Altogether there must have been an immense quantity of *kokowai* used, and an incredible amount of labour expended in the preparation of it. Most of the old writers speak of the prevalence of the "red ochre," and it seems to have been in universal use throughout the whole of the Maori-inhabited country.

The grinding-slab was usually a flat piece of hard coarse-grained sandstone about 2 ft. long by 12 in. to 15 in. wide, the same kind as that used for sharpening the stone implements.* All those found about the Bay of Islands appear to be of the same quality as the specimen before us, which has evidently been used for both purposes, as, though each surface bears marks of abrasion, only one shows traces of the red pigment. A favourite place for obtaining these stones is situated near Waimate North, where the rock naturally splits off into flags of the required thickness.

The rubbers (*autoru*) were generally smooth beach- or river-worn pebbles, about 6 in. long, of hard basalt or volcanic stone. They were often brought long distances, especially in the northern peninsula and in inland districts where no suitable stones are to be found. A favourite place for obtaining them was the Little Barrier Island, but it is not improbable that on their more distant excursions down the east and west coasts the Maoris would keep a look-out for good specimens, which they would bring back with them on their return to their homes. It is to be hoped that in time some of these will find their way into the Museum, when geologists will, no doubt, be able to locate their places of origin, and perhaps

* Though I have inquired of many of the old natives in the district, I have been unable to obtain the specific name for the grinding-slab. One Maori told me that each slab had its proper name. This, I think, is not improbable.—P. W.

throw some unexpected sidelights on the past history of the race.

A good grinding-slab was a valuable article, and was prized accordingly. They were generally, if not always, *tapu* (consecrated), and in order to insure their safe keeping and preserve them from desecration they were usually deposited in some *wahi-tapu*, or holy place, which no common person would dare to enter, and which the *tohunga* (priest) would only visit formally and officially. In later times, when the fear of the *tapu* began to wear off, the stones were sometimes buried underground for additional security in a spot only known to one or two of the *tohungas* or chiefs of highest rank. As an instance of the dread of the *tapu* even within the memory of persons now living, I may mention that as late as forty or fifty years ago one of these slabs was ploughed up on the Mission farm in the Waimate, where some land was being prepared for a crop of potatoes. A young girl who had thoughtlessly handled the stone was warned of the danger she had incurred, and actually died of fright a few days afterwards. In another case a stone which was identified as one formerly used for preparing *kokowai* for a chief was accidentally found in a wooded gully, and the whole place was at once declared *tapu*, and none of the timber could be used for cooking until an elaborate ceremony of *whakanoa* had been held, when the spot was "made common."

The question has naturally been raised as to the purpose intended by the use of the *kokowai* as a cosmetic. Dr. Shortland remarks that "a reason for some persons painting their body and clothes was that they might leave a mark behind them, that people might know where their sacred bodies had rested" ("Traditions of the New-Zealanders," p. 112). There may be something in this, but that it was not the only reason is evident from the fact that the painting of the body was not confined to chiefs of particular note, but was practised by men generally of the *rangatira* class. *Kokowai* was, like the purple of the Romans, a sign of rank, but not reserved exclusively for persons of the highest station. From Polack's account, already quoted, it will be seen that it was in general request among men of fashion at the feast which he describes; and Bidwell observes that in his time it was impossible to be carried by a native without getting one's clothes soiled by the "red dirt" which had saturated their mats ("Rambles in New Zealand," 1841, p. 35). Though probably certain distinguished individuals kept themselves painted at all times, the minor *rangatira* appear to have been decorated only on festal and ceremonial occasions, one of which was the starting on a hostile expedition, when the whole party were arrayed in full "war-paint." There is no doubt that one of the prin-

cipal objects in the application of the *kokowai*, with its admixture of shark-oil, was at once to protect the body from the changes of temperature and from the annoyance of sand-flies, mosquitoes, and certain parasitic insects which seem to have been very abundant among the old-time Maoris, and afflicted all classes alike (see "Cook's Voyages"). This double purpose would probably be fairly accomplished by the strong-smelling oil alone, but the addition of the earthy matter would doubtless render the application more effective, and at the same time give it an aristocratic appearance. So far as I have been able to learn, this use of the *kokowai* was exclusively confined to the male sex, women and girls using various pigments derived from the pollen of flowers and other vegetable sources in small spots or patches on their faces.

Though there were several shades of *kokowai*, according to the quality of the article, the general and favourite colour was a rich warm red something like that of a well-burnt brick, with a "mat" surface. When used for the painting of a war-canoe it was relieved with black, and occasionally with white. Thus, the hull and topsides were invariably red, and the figure-head and stern-post, as well as the long batten which covered the joint between the hull and topsides, were usually a lustrous black, while for several feet under the bows a running pattern was painted in black and white suggestive of the rippling of the waves. The effect of this combination was most striking and beautiful, especially when the head and stern pieces were further decorated with their ornament of kaka (parrot) and pigeon feathers, and the covering-batten spaced at intervals with the white plumes of the gannet.

On the great wooden images carved on the principal posts of the palisading of the pas, on the entrance-gates, on the barge-boards and the door and window pieces of the house, and, in fact, on all carved work whatsoever, the *kokowai* always formed the general ground tint; and a contrast was obtained by picking out some of the smaller details—*e.g.*, the *moko*, or tattooed pattern on the faces or bodies—in black, the effect being further enhanced by the insertion of pieces of paua-shell (*Haliotis*) for the eyes of the figures.

For interior decoration the *kokowai* was specially adapted. It formed the ground colour of the massive slabs or pilasters which spaced off the walls into panels and supported the roof. These in a large tribal meeting-house were elaborately carved with a succession of grotesque semi-human figures with eyes of the iridescent paua-shell and the wonderful convolutions of the *moko* picked out in black. On the broad rafters the prevailing red and black alternated in filling up the spaces between the scrolls of a bold running pattern in white. Several excellent samples of these rafter-patterns are repro-

duced in colour by the Rev. Herbert Williams in Part II. of Hamilton's "Maori Art."

The *kokowai* met the eye of the Maori at every part of his surroundings during his lifetime, and did not leave him even in death, as it was the custom, after the bones of a chief had been scraped clean at the *hahunga*, or ceremonial feast held for the purpose, to give them a coating of his favourite colour before they were deposited in their final resting-place.

As prepared by the Maoris in the old time the *kokowai* formed a paint of extraordinary permanence and durability. A piece of carving in the possession of Mr. W. H. Skinner was exposed to the weather for at least sixty years, but on all sound portions of the wood the colour is still quite strong and fresh. A still better example, if possible, may be seen on my grinding-slab. This, together with the rubber, was found in the vicinity of an old pa near Waimate, which has not been occupied within the last two centuries. The two stones lay together at the edge of a bush in a spot which must have been overrun by innumerable fires, the heat of which was sufficient to scale the hard basalt of the rubber; but in spite of this exhaustive test the *kokowai* is still there. Neither sun, rain, fires, nor the lapse of time has been able to obliterate it.

Though it may have been well on æsthetic grounds, as a general rule, to restore the Maori carvings in our museums to something like their original appearance with a fresh coat of paint, I think it would be interesting to leave a few good specimens untouched, as, apart from the fact that these weather-worn objects have a beauty of their own which it is a pity to destroy, it would be an advantage to have an opportunity of seeing how this wonderful mixture is capable of enduring the most trying conditions.

On the origin of the name *kokowai* Mr. S. Percy Smith, F.R.G.S., in a note on the subject kindly sent to me, thinks that the word is probably derived from the colour. *Koko*, he says, is evidently connected with colour, *kokouri* and *kokotea* meaning respectively dark- and light-coloured. *Koko* is also connected with a strong or unpleasant smell. On the term *horu*, a common name for a variety of the *kokowai* (see above), Mr. Percy Smith quotes from "L'Anthropologie" for August, 1891, as follows: "There is no doubt that in certain Egyptian myths there is connection between Horus, the sun god, and Iron," and asks, "Is not the Maori name *horu*, the name for an oxide of iron, derived from the same source?"

Art. III.—*Moriori Carving on the Trunks of Karaka-trees.*

By A. Hamilton.

[*Read before the Otago Institute, 3rd December, 1903.*]

Plate III.

A recent paper in the "Annals of Botany" on the genus *Corynocarpus** draws attention to the remarkable character of the genus, and to the fact that up to the present time it has not been found outside certain parts of the Colony of New Zealand. Now, however, it has been found that New Caledonia and the New Hebrides have what is practically the same tree so far as the fruit is concerned, the specific differences being based on small variations in the flower.

The *Corynocarpus*, under the name of "karaka," has long been reputed to have been brought to New Zealand by one of the canoes from distant lands.† One of the earliest of these traditions, given by Mr. Shand in his valuable notes on the Chatham Islands, is to the effect that Maruroa and Kauanga brought the karaka-berry from Hawaiki in the "Rangimata" canoe and planted it all over the island, the places where it was set being named. They planted it first at a place which they called Wairarapa, that being their name for the tree (according to one statement), near Te Ika-rewa. Mr. Shand says that it is found growing plentifully not far from the sea-shore on the main island and in Pitt Island wherever the soil is at all suitable, but not in the higher parts of the southern portion of the main island. He also notes that the natives used certain incantations or spells to insure a good crop of the berries. The kernels when gathered were cooked in a native oven, or *umu*, then put into flax baskets and the outside pulp removed by trampling with the bare feet, after which they were steeped in water for not less than three weeks to remove the poisonous element—the same process as the Maoris practised.

Many years ago the late Mr. W. T. L. Travers‡ drew attention to the various marks which his son saw on the trunks of the large karaka-trees, and states, the quarrels of the Morioris "appear to have arisen chiefly out of conflicting claims

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* "On the Genus *Corynocarpus*, Forst., with Descriptions of Two New Species," by W. Botting Hemsley. Ann. Bot. 17, p. 743, 1903.

† In his account of the coming of Turi the navigator to the west coast of the North Island of New Zealand in the "Aotea" the Rev. T. G. Hammond says, "On the north bank of the [Patea] river is Papa-whero, where Turi planted the karaka-seed from Hawaiki, which grew to trees and flourished till the war with the Europeans, when the parent stock was destroyed" (Polynesian Journ., vol. x., p. 194).

‡ Trans. N.Z. Inst., 1876, vol. ix., p. 15 (see p. 22).

to the possession of valuable karaka-trees, the fruit of which was a staple and much-liked article of food, . . . nearly all the older karaka-trees on the island are marked with devices indicating their special ownership—a fact of very great interest. . . . These figures are very rude, but were evidently sufficient for the purposes of the owners."

Captain Mair,* in the discussion which followed on the reading of the above paper, did not agree with Mr. Travers regarding the individual ownership of the karaka-trees, as these trees covered a third of the island, and their fruit must have been more abundant than the small number of the inhabitants could consume. Dr. Cockayne, who has recently explored the island botanically, draws attention to the large number of trees in the bush, and is evidently of the opinion that the karaka is indigenous; so the question as to whether the tree was indigenous to the island or was planted there by the early inhabitants is as much in doubt as ever.

Lately a number of the marked trees have been cut down, and there are now several examples of the carvings in the Christchurch and Wellington Museums, and for a photograph of one of the oldest and most characteristic I am indebted to Mr. J. J. Kinsey, of Christchurch. It represents, in the conventional manner found in old cave paintings, a human being. It has been deeply cut through the bark of the tree down to the wood. The photograph is an excellent one, and shows the rounded swelling of the new growth of bark very well. Most of the other specimens that I have seen have had the figure indicated by incised lines, and are probably much more modern than the one figured.

In connection with this marking of trees, it should not be forgotten that the Rev. R. Taylor† states that sacred trees are common on the east coast of New Zealand. In the Bay of Plenty, he says, they are generally to be discerned by being painted red, or bound round with garments, or having rags suspended from their branches. Although there is every probability that these trees were karaka-trees, it is not so stated. If they had not been "on the coast," the usual habitat of this tree, we might have concluded that the trees were reserved, or tapued, by chiefs for the sake of their bark for tanning purposes, or for their timber, such as are still to be seen in the Urewera country.

The following extract from the first-quoted paper is an interesting part of the botanical history of the genus: "*Corynocarpus* was established by the Forsters in 1776 (Char. Gen. Pl. Ins. Mar. Aust., p. 32, t. 16), and, although the descrip-

* Trans. N.Z. Inst., 1876, vol. ix., p. 621.
† "Te Ika a Maui," 2nd ed., p. 20.

tion is incomplete and the figures of the parts of the flower inaccurate, there can be no question about the tree intended. It was described from specimens collected in New Zealand on Cook's second voyage (1772–75), and the perfect fruit seems to have been unknown to the Forsters or they would hardly have given it a name signifying club-fruit. They were evidently unaware, too, that the fruit of *Corynocarpus* is edible, or it would have been included in G. Forster's 'De Plantis Esculentis Insularum Oceani Australis.' But Sir Joseph Banks and Dr. Solander, who were the botanists on Cook's first voyage (1768–71), also brought specimens of this tree to England, and it was described and figured by them under the name of *Merretia lucida* (in memory of Christopher Merrett, M.D., author of 'Pinax rerum naturalium Britannicarum,' 1661). The authorities of the Botanical Department of the British Museum have obligingly furnished me with a copy of the description, which is very full, and accurate in most of the details. The most important point in which it differs from what I have observed and what other authors have described or figured is the shape of the petaloid staminodes. They describe them as 'apice tricuspidata, cuspide intermedio duplo maiore.' The staminodes of *C. similis* and *C. dissimilis* are acutely toothed at the apex, whilst those of *C. lævigata* are irregularly and minutely toothed from about the middle upwards and around the top. There can be no doubt about Banks and Solander's specimen having been brought from New Zealand, because exact localities are given, and because Cook did not visit the New Hebrides on his first voyage. On the second voyage he touched at several of the islands; but the Forsters record their *Corynocarpus* from New Zealand, and their figures and description of the staminodes convey no information whatever beyond the presence of such bodies in the flower. Banks and Solander also describe a fully developed fruit in the following terms: 'Drupa oblongo-ovalis, glaberrima, lutea, magnitudine Olivæ Hispanicæ (1⅓ unc.), substantia carnosa, lutea sesquilineam crassa edulis.' They further describe the 'nucleus' (seed) as 'amarissimus.' . . . In 1823 or 1824 it appears to have been introduced into English gardens. . . . A. Cunningham, in 1840 ('Floræ Insularum Novæ-Zelandiæ Precursor,' in Ann. of Nat. History, iv., p. 260), gives a Latin description of all the parts except the fruit, and cites Banks and Solander's manuscript name. He is also the first, so far as I am aware, to explain the process by which the Maoris got rid of the poisonous properties of the seeds and rendered them edible."

With regard to the first notice of karaka-berries as food, Polack gives the name *kou* as "the steamed kernels of the native fruit karaka." His work was published in London in 1840.

ART. IV.—*Maori Marriage Customs: being Notes on Ancient Maori Customs, Ritual and Sociological, connected with Courtship, Marriage, and Divorce, together with some Account of the Levirate, and of many Superstitious Beliefs, and Ancient Animistic Myths connected with the same, as held and preserved by the Maori Peoples of the Tuhoe Tribe.*

By ELSDON BEST.

[*Read before the Auckland Institute, 5th October, 1903.*]

IN works treating on Polynesian ethnology and sociology the subject of marriage is invariably disposed of in a few sentences. The writer usually states that there was no marriage rite among these peoples, but that, in New Zealand, a custom obtained by which young people were betrothed to each other. Others have said that a formal handing-over of the woman to her husband was usual in New Zealand. These brief remarks show a surprising paucity of information, and are often rendered in such a manner as to give readers the impression that marriage among the Maori people was, in former times, but a low type of cohabiting, to which no ancestral customs, forms, or rite pertained. I propose to show in this paper that these scant accounts are misleading, and that the impressions left on the reader's mind after a perusal of the same are quite erroneous.

The Maoris were ever a most punctilious people, and ever adhered rigidly to ancient customs and forms, social and otherwise. No exception was made in regard to such of these as related to marriage. They might occasionally be ignored by young people, but if so the tribal opinion, or that of the sub-clan or family group, would at once condemn such a breach of custom. I propose, then, to show that — First, there was a marriage rite among the natives of New Zealand. Secondly, a recognised and enforced mode of procedure obtained in regard to marriage, the arrangement of which was conducted by the elders of the interested couple. There were, undoubtedly, exceptions to the above arrangements, but these exceptions are no proof that such rules were not generally recognised, and upheld. The same might be said of our own marriage system, which is by no means universally followed among us. For instance, the rite, which will be explained anon, was performed over parties belonging to the *rangatira* class only—*i.e.*, persons of good birth—but never over low-born persons (*tutua* or *ware*); but even in the case of the latter the marriage would not be a formless pairing or cohabiting, but would be proposed, discussed, and arranged, with possibly

little ceremony, but nevertheless deliberately and properly adjusted.

The description of such customs, &c., pertaining to courtship, betrothal, marriage, divorce, and other matters as will hereinafter be described has been obtained entirely from members of the Tuhoe Tribe of Maoris, who have inhabited for centuries the rugged district situated between the Bay of Plenty and Te Wairoa, on the East Coast. This article does not assume to be a description, or even a compendium, of the marriage customs of all the native tribes of New Zealand. Differences in customs, &c., are sure to be found as between different tribes.

The system of ethology, or code of ethics, of the Maori in former times was suited to a communistic and primitive people, and, like their religion, was more closely adhered to and upheld than the systems, moral and religious, of many more-advanced peoples. To marry any one of closer kinship than a third cousin was deemed incest, and great exception was taken to such unions. They were severely condemned.

In order to understand the following notes on the Maori marriage system it is necessary to have a clear idea of the tribal organization of these people, and their system of consanguinity.

The natives of New Zealand base their tribal organization on their descent from the last and most important migration of Polynesians from the isles of the Pacific, although they are also descended from the ancient tribes of the land, a prior migration of a similar ethnic people. This latter origin is, however, not much heard of, as the *mana* (power, prestige, &c.) of the old-time people passed away and was replaced by that of the descendants of the last migration, which arrived at New Zealand about the middle of the fourteenth century. Thus, the Tuhoe Tribe, although principally of aboriginal blood (of the earlier migration), have long discarded their ancient and more applicable tribal name of Nga-Potiki for that of Tuhoe-potiki, who was a chief of the descendants of the latter migration.

The collection or group of peoples, termed *iwi* (tribes) by the natives, are subdivided into *hapu* (sub-tribes or clans), and these again into sub-*hapu* or family groups (also termed *hapu*).

Edward Jenks, in his "History of Politics," says that the tribe "is a large group, consisting of several hundred individuals, the fully qualified among whom certainly believe themselves to be descended from a common male ancestor. . . . But in most cases the common ancestor of the tribe is a fictitious person," &c. The other social unit he

terms the clan (or *sept*). This, he says, "is a much smaller body, consisting of some three or four generations only, in descent from a perfectly well-known male ancestor," &c. Now, these remarks are not applicable to the social organization of the Maori people. Jenks's "tribe" is equivalent to the Maori *hapu* or sub-tribe. His "clan" is the Maori sub-*hapu* (or sub-clan). In former times it was a poor Maori tribe indeed that could not muster a thousand fighting-men. Also, among the Maori a common ancestor of a tribe is by no means a fictitious person. The Maori clan or sub-tribe may be descendants of an ancestor who lived ten, or fifteen, or more generations ago, and may consist of hundreds of individuals. Certainly it would appear that in some cases—*e.g.*, the Arawa—the primal social unit might be termed rather a group of tribes, a league. But in cases where all members thereof are descended from a common ancestor, and, however non-cohesive in times of peace, yet group themselves ever together in defence against an extra-tribal enemy, and act in other important matters as a political entity, then such a people, or collection of peoples, must be looked upon as a tribe.

The unit of the social organization of the Maori is, I take it, the consanguineous family group or sub-clan (*i.e.*, sub-*hapu*). Now, it would entirely depend upon the numbers of such a sub-clan as to whether the members thereof would or would not be required by native custom to contract exogamous marriages. Even then such unions would not be exogamous in regard to the tribe or *hapu*. As a tribal matter marriages were usually endogamous in former times. We will, however, make this matter clearer by means of the genealogy of a portion of a sub-*hapu* as an illustration. Prior, however, to entering upon a description of Maori marriage we will tarry a while with the gods, and invade the realm of myth and animism.

Animistic Myths and Mythical Origin of Marriage.

In this paper I make use of the term "marriage" to denote the union or cohabiting not only of the *genus homo*, but also of gods, heroes, mythical beings, personifications, and animated natural objects and phenomena.

The most remote allusion to sex in Maori mythology pertains to the period, long anterior to the existence of Rangi and Papa-tuanuku (the Sky and Earth), when certain primordial beings or personifications existed in the primitive chaos from which the elements and all living beings have sprung. These beings are said to have been bisexual, and to have produced offspring down to the time when earth and sky were so formed, after which the progeny and descendants of the

latter appear to have been more distinctly anthropomorphous; at least, they are credited with human passions, and are said to have performed divers manual feats and tasks.

The primal beings above mentioned would seem to have been animistic conceptions, personifications of eras and æons of time. They represented chaos, they emerged from nothingness, from the dark void, from the womb of time. They were the origin of the Maori cosmos, and as time rolled on the universe became more ordered, the elements came into being through the same agency of sex, the heavenly bodies appeared as offspring of sexed personifications, after which came the heroes of Maori mythology, gods and demigods, and then man appeared—that is to say, man as we know him, man of the world of light, the world of life and being. Such is, in few words, the spirit of the Maori cosmogony and anthropogeny, as also the origin of sex. In fine, Maori myths and origins are noted for the mytho-poetic ideas and animistic conceptions which they contain and are based upon.

When Rangi and Papa, the Sky Parent and the Earth Mother, came into being they embraced each other as husband and wife, and produced certain beings who were the origin or personification of trees, birds, fish, winds, war, peace, &c.; and these children, objecting to the state of darkness in which they lived, on account of the sky lying pressed down upon the earth, cast about for a plan whereby they might enjoy light and space. This ended in their forcing their parents apart. Tane, tutelary deity of trees, forests, and birds, thrust the sky upwards and propped it up with poles. Observe here the origin of divorce, and the name thereof. *Toko* (noun), a pole; also, a ray of light. *Toko* (verb), to propel with a pole. Now, the Maori term for divorce is *toko*, and in the invocation repeated by the priest during the performance of the divorce rite occur the words—

Ka tokona atu nei korua
Tu ke Rangi, tau ke Papa—
(You two are forced apart as were Rangi and Papa).

But of divorce and its ritual more anon. We have not yet married our Polynesian couple.

The first marriages mentioned in Maori myth in which members of this world (*te ao marama*, the world of life, light, or being) were concerned were those of Tiki and Tane. Tiki, who was of the *Po* (world of Darkness or Chaos), married Ea,* who was of this world. They had Kurawaka, who married Tane-nui-a-rangi, one of the offspring of Rangi and Papa. Hence the expression *Te Aitanga a Tiki* (the Offspring of Tiki) is applied to man by the Maori people.

* Compare Ea of Phœnician mythology.

Tane sought long for woman ere he found her. He married many singular beings and produced offspring of passing strangeness ere he came to Kurawaka. For instance, he married Hine-tu-maunga, and produced Para-whenua-mea (personification of flood-waters). He married Hine-wao-riki, and had the *kahika* (a forest tree). He married Mumuhanga, and produced the *totara* (a forest tree). He married Tukapua, and had the *tawai* (a tree which grows on high ranges). He married Mango-nui, and had the *tawa* and *hinau* (both trees). He married Te Pu-whakahara (a star name), and had the *maire* (a tree). And so on, a long list of such unions, until he went to Rangi and asked, "Where is the *uha* (female, or female nature)?" And Rangi said, "The *whare o aitua* is below." Then Tane came and found woman of this world. The expression *whare o aitua* appears to mean "the origin of misfortune and death," and to be applied to the female sex or nature. Even so, Tane came to earth and found woman. And the Maori people trace their descent from Tane, as they do from Tiki. Thus, also, the trees of the forest are their distant relatives, fellow-descendants of Tane. And this is one reason why the Maori is so close in touch with nature. He speaks of the forest trees as if they were sentient beings; he fells a tree and says, "Tane has fallen"; he performs strange rites in order to placate the gods of the forest; he peoples the forest depths with singular beings.

In Maori myth the heavenly bodies are credited with the possession of sex and of human attributes. The sun has two wives, Hine-raumati and Hine-takurua, the Summer Maiden and the Winter Maiden. The star Rehua (Antares) has also two wives, Whakaonge-kai and Ruuhi, the latter being also known as Peke-hawani. The moon, which is deemed a male, has two wives (perhaps I should say two legal wives, inasmuch as the moon is said to be the husband of all women, and is the cause of menstruation).

Such animistic illustrations might be given *ad nauseam*, but we will now give a few items from the Tuhoean folklore tales. The Tuhoe Tribe were originally known as Nga-Potiki, the Children, or the Descendants of Potiki. These aborigines are descended from one Potiki, a remote ancestor, whose origin was a most singular one, as follows: One Hine-pukohu-rangi is the personification of mist in Tuhoean myth. It was this Maid of the Heavenly Mist who lured to earth Te Maunga, the Mountain, and from the union of these two sprang Potiki (the Child), from whom sprang Nga Potiki (the Children, or Descendants of Potiki), who are now known as Te Ure-wera and Tuhoe. They are the Children of the Mist.

A similar being seems to have been one Tairi-a-kohu, who descended to this world in order that she might bathe in the

waters thereof. She was captured by Uenuku, who kept her as his wife, but she only remained with him during the hours of darkness, returning at dawn to celestial regions. But Uenuku revealed her to his people, and she then left him, returning nevermore. And Uenuku wandered to far lands in search of his lost bride until death came to him. But ever he is seen in the form of a rainbow when Tairi-a-kohu, the Mist Goddess, appears.

Before leaving the realm of myth there is one other singular item of folklore to be mentioned—viz., the animising of natural objects. For instance, there are strange legends concerning the mountains of the Taupo district and their doings in the misty past. Rangi (see *ante*, the Sky Parent) married Tongariro (a male mountain) to Pihanga (a female), and the result of that union was rain, sleet, snow, and gales. Among these mountains quarrels arose, hence Taranaki (Mount Egmont) migrated westward, while Kakara-mea, Maunga-pohatu, and others went towards the Bay of Plenty. Putauaki* had a great admiration for Maunga-pohatu, and expressed his love by means of a song. This affair does not seem to have ended very happily, for those two mountains still stand many leagues apart. Another singular and more modern instance of mountain-marriage occurred about eighty years ago, when the long war between Tuhoe and Kahungunu Tribes came to an end. To bind the peacemaking Hipara, a chief of the latter tribe, gave his daughter, one Hine-ki-runga, as wife to a Tuhoe chief. Also, to make the matter more secure, two big hills near Waikare-moana were married; the one, Turi-o-Kahu, was "set up" as a male, the other, Kuha-tarewa, as a female. Thus these solid hills were joined together as a sign and token of enduring peace.

We will now turn to the marriage Maori, and describe the ancient customs of the mountaineers of Tuhoeland in regard to these matters.

As to Exogamy and Endogamy.

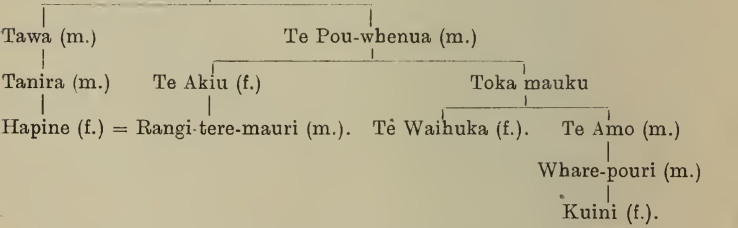
When making inquiries as to the marriage customs of primitive peoples it is desirable to first ascertain as to whether the system of marriage is exogamous or endogamous, after which the lines of inquiry are the more easily ascertained and followed. In regard to the Maori people of New Zealand, they may be termed an "endogamous" people, albeit exogamous marriages are of more frequent occurrence now than they were in former times, before European settlement put an end to the intertribal warfare and broke down to a certain extent the barriers which existed between the various tribes; for the

* Putauaki is the native name of Mount Edgecumbe.

Maori people, like so many other races, could never form themselves into a nation, but were ever split up into many tribes, who waged war against each other for long centuries.

The Maori were endogamous in regard to the tribe and the sub-tribe or clan (*hapu*), and also to some extent in regard to the sub-*hapu*—*i.e.*, the *gens*, or family group. Not that marriages did not take place as between members of one *hapu* and those of another, or even between those of one tribe and another. Such marriages did occur, the latter, however, much more rarely than the former. Still, it was considered desirable to marry within the *hapu*, or clan, for social and political reasons. Marriages between members of one tribe and those of another were generally of a political nature, as to cement a peace-making. We are speaking of pre-European days now, for latterly extra-tribal marriages have become more frequent.

As to marriages between members of the same sub-*hapu* (*gens*, family group), it would depend entirely on how many generations that group was composed of—*i.e.*, in regard to the number of generations of descent of the members thereof from a common ancestor. The custom among the Tuhoe Tribe is simply this: the members of the third generation of two divergent lines from a common ancestor may intermarry. Observe:—

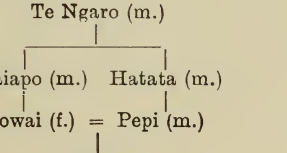


Here we have Tawa and Te Pou-whenua, both sons of Rangi-ka-whetui. Tawa had Tanira, who had Hapine. Te Pou-whenua had Te Akiu and Toka-mauku. Te Akiu had Rangi-tere-mauri. Toka-mauku had Te Waihuka and Te Amo. The latter had Whare-pouri, who had Kuini. Now, when Hapine and Rangi wished to marry an objection was raised by some members of the tribe on the ground that the connection was too close and that the marriage would be an incestuous one. This objection was overruled—in the first place because it was shown that Hapine and Rangi were of the third generation from a common ancestor—viz., Rangi-ka-whetui; and, secondly, because the marriage was arranged in due form (*he mea ata whakamoe*) by the parents of both and by the tribe. Hence no further opposition was made, and the

couple were duly married. Nor are they ever reproached with having transgressed tribal custom. But Tanira would not be allowed to marry Te Akiu, because they are only the second generation from a common ancester. Such a union would be looked upon as being incestuous. Nor could Rangi marry Te Waihuka, for the same reason. Te Amo might marry Hapine, though possibly some of the tribe might have objected, as in the case of Rangi; but such opposition would break down if the couple persisted, as shown above. The natives say that it is only among dogs that near relations have connection with each other.

Half sisters and brothers are not allowed to marry, they being looked upon as are full brothers and sisters, a relic possibly of a system of maternal filiation of remote times.

Now we will show an incestuous marriage which took place in this district a few years ago, and which was bitterly condemned by the tribe:—



Here Towai married Pepi, and both are of the second generation from a common ancestor—viz., Te Ngaro. These two are first cousins, but according to the consanguineous nomenclature of the Maori they are termed "brother" and "sister" to each other. Hence this union is looked upon as incestuous, and is spoken of as "*He ngau whiore, he whakahouhou*" ("It is incestuous, it is disgusting"). Disparaging allusions to the above couple are often heard. Such unions are infrequent, and, it would appear, universally condemned.

It will thus be seen that the Maori were an endogamous people, and are so still to a great extent. Doubtless it was deemed desirable to keep as many fighting-men within the clan-limits as possible in the warlike days of old.

In regard to exogamous marriages, the following proverbial saying explains the situation: "*Te inati o Mawakeroa*" is used to denote that when a woman marries into another tribe or clan she and her *mana* are lost to her people and clan. She goes to live with her husband, and returns no more. But a son dwells with us, and we have the advantage of his *mana* (prestige, &c.), strength, knowledge, and so on; a son remains with his people, not so a daughter.

Many statements met with in various ethnographical works concerning the customs of primitive peoples and

others are often misleading when we apply them to a race whose customs are known to us. Too much is taken for granted; many assertions are too general. In "The Primitive Family," by C. N. Starcke, we read, "The tribe is endogamous, but the clan or sub-tribe is exogamous—*i.e.*, a person must always marry out of the sub-tribe." This statement, as we have seen, does not apply to the Maori of New Zealand. The same writer says, "No people are exogamous as a tribe, only clans or sub-tribes are so." It is quite certain that no Maori tribe was exogamous; neither were the sub-tribes.

As a consequence of the Maori recognition of both agnatic and uterine filiation, it follows that property is inherited through both parents, as also is rank and prestige. Property inherited consists principally of land interests. Hence it follows that the native claims to land are often most intricate and difficult to adjudicate upon, as our Native Land Court Judges know full well. The children born of exogamous marriages were entitled to an interest in the lands of both parents, providing that such lands were occupied by them. In such cases it is the custom to live for some time at one place, cultivating food there, and utilising the various natural products of the land, and then to go and live on other lands wherein the person is interested. Thus both claims are kept up, according to Maori custom.

One kind of exogamous marriage among the Maori was the result of their frequent intertribal wars, in which many of the conquered people were enslaved. It was by no means uncommon for a native, even the chiefs, to marry a slave wife, and the children of such an union would inherit their father's rank and property. They would continue to live as members of their father's tribe, by whom they would be better treated and more honoured than they would be by their mother's tribe should they return to it; for on that side the degrading stigma of slavery would lie upon them—there were, in fact, dead to the mother's tribe.

When the Tuhoe Tribe expelled Ngati-manawa from Te Whaiti that stricken people took refuge with the Kahungunu Tribe, to whom they paid a tribute of preserved birds, &c., for being allowed to dwell in those parts. However, they got into trouble with one tribal section of their overlords, and were in sore straits, when a Tuhoe chief went and brought the remnant away to Rua-tahuna. Here many of Tuhoe wished to slay them, but several chiefs of Tuhoe, in order to save the lives of the fugitives, gave some of them women of the Tuhoe Tribe as wives. Hence the refugees were safe, and through those women are the Tuhoe and Ngati-manawa Tribes connected.

Andrew Lang, in his "Custom and Myth," says, "On

the whole, wide prohibitions of marriage are archaic: the widest are savage; the narrowest are modern and civilised." On this basis the marriage system of the Maori may be termed civilised, inasmuch as not only could a person marry another of the same clan-name, but also one of the same *gens* or family group, providing that they were at least of the third generation from a common ancestor. So long as this rule was respected no very serious opposition to a marriage would be made by these people. A young man might inform his elders that he wished to marry a certain relative of his. His elders would remark, "*E moe korua ko to tuahine, kia kai iho ano korua i a korua*"—*i.e.*, "Marry your sister, that you may assail each other"—the meaning of the remark being that it is desirable to marry within the clan, and that when the couple quarrelled and proceeded to *kai upoko*, or curse each other, the remarks would not be so serious coming from a relative as they would if they were uttered by a non-relative. The epithets would not in the above case be deeply resented, or be treasured up as a wrong to be avenged (*kaore e mamaetia*). In regard to the use of the term "sister," a perusal of the table of consanguineous nomenclature, to follow, will explain this.

Filiation, Consanguineous and Affinitative Nomenclature.

Letourneau, in his work "The Evolution of Marriage," states that "filiation by the female line seems to be generally adopted in Polynesia." This statement is misleading in regard to the natives of New Zealand, where kinship is certainly claimed through either or both parents. This is probably the result of the system of permanent marriage which here obtained, and which has evidently been in force for many generations. The various tribes and clans (*hapu*) are usually named after male ancestors, but some after females. Such a tribe or *hapu* (sub-tribe) consists of the descendants of such ancestor. Thus, Ngati-Tawhaki (the Descendants of Tawhaki), a *hapu* of the Tuhoe Tribe, is composed of the descendants of Tawhaki, who lived nine generations ago; Ngati-Tuhea, a sub-*hapu* (*gens* or family group) of Ngati-Tawhaki, are the descendants of Tuhea, who flourished four generations back; while Ngati-Hinekura are the descendants of a woman named Hinekura. Blood relationship was, and is, counted through both parents. The rank of chiefs is transmitted through both the male and female lines. Perhaps the descent through first-born male children of chiefs—*i.e.*, *aho ariki*—was, and is, most highly esteemed, but the mother, if of high birth, and more especially if an eldest daughter, had, and has, great prestige and

influence. Unless property inherited be from the mother alone, it might be said that the order of succession of inheritance was from father to the eldest son, perhaps later to the younger children, but always with the tendency to revert to the offspring of the eldest son. In the work above quoted is a statement to the effect that, under European influence, the Maori of New Zealand have adopted agnatic filiation, "but this new system still jars against ancient usages, which formerly harmonized with the maternal family." I quite fail to see how agnatic filiation can be said to be new among the Maori, when for centuries past rank and *mănă* (prestige, power) have been transmitted through both the male and female lines of descent. Uterine filiation is of undoubted importance among the Maori, especially when conveying rank; but the male line appears to have been equally important, and the *ara tane*, or male line of descent from a noted ancestor, is looked upon with pride by the descendants of such ancestor. Given the fact that both parents were of equal rank, it is possible that greater weight would be given to masculine filiation; but if the mother was of higher rank than the father, then their children would prefer to trace their descent through the mother, with whom their increased rank and prestige originated.

In claiming land in the Native Land Courts of the colony a native may claim through either or both parents, the latter course being adopted when he has a claim through both. If his mother only held an interest in the land, then he would, of course, claim it through her alone, and give his genealogical descent through her. The same process would be adopted if only his father had an interest in such lands.

There is no evidence to prove that the matriarchate system prevailed among the Maori, whose system of filiation may appear somewhat peculiar, inasmuch as, as we have seen, rank, property, and *mana* (prestige, power, authority) was transmitted by both the male and female lines. It is perhaps needless to state that the group-marriage system was unknown among the Maori. Polygamy existed to a certain extent, but only among men of rank. If ever the matriarchate existed among the Maori, then it must have been in times long passed away, though possibly the estimation in which the maternal line is held when endowed with rank may be a survival of that ancient system.

The Maori recognised a difference between real filiation and adoption. A man could marry the adopted daughter of his parents, provided that she was not nearly related to him.

In regard to consanguineous nomenclature, it may be stated that degrees of relationship are not by any means clear as used among the Maori, as will be seen anon.

Deniker, in his "Races of Man," says that the "classificatory system"* obtains among the Maori. To this, as described by him in chapter vii. of the above work, a qualified assent may be given. He seems, however, to imply that exogamy and group marriage obtained among the Maori, which is quite erroneous.

But this much is correct: In the Maori system of consanguinity *myself*, my brothers, sisters, and cousins are all termed "brothers" and "sisters." Also my father, with his brothers, sisters, and cousins, are all termed "brother" and "sister" to each other; and so on. My children and their cousins form another such group. But the second group, given above, does not include my mother, as Deniker states. He is right, however, in stating that I, as a Maori, would term the children of my brother or sister "my children," and their grandchildren as "my grandchildren."

We now submit an abbreviated list of terms of the consanguineous and affinitative nomenclature of the Maori people, which will illustrate the above remarks.

System of Maori Nomenclature, Consanguineous and Affinitative.

The Person spoken of. Degree of Consanguinity.	The Speaker.	
	Male. Term used.	Female. Term used.
Father	Papara (true or real father	Same.
	Pāpā	„
	Mātŭa(1) tānē (male parent)	„
Mother	Kokara (real mother)	„
	Whāeā	„
	Kōkā	„
	Matua wahine (female parent)	„
Elder brother	Tŭakāna	Tŭngāne(2).
Younger brother	Tāinā or tēinā ..	„
Elder sister	Tŭahīn	Tŭakāna.
Younger sister	„	Taina or teina.
Father's brother	Pāpā	Same.
„ sister	Whaea or Koka ..	„
„ mother	Kūīa	„
„ father	Kŏrŏuā	„

(1) *Mātŭa* means simply "parent." Becomes *mātŭa* in plural.
(2) *Tungane* simply = brother of a female, a generic term for brothers, not for elder brother only.
(3) *Tuahine* simply = sister of a male, a generic term for sisters, not for elder sister only.

* See L. Morgan's "System Consanguinity" and "Ancient Society."

SYSTEM OF MAORI NOMENCLATURE, CONSANGUINEOUS AND AFFINITATIVE—*continued.*

The Person spoken of. Degree of Consanguinity.	The Speaker.	
	Male. Term used.	Female. Term used.
Father's mother's brother ..	Kŏrŏuā	Same.
„ „ sister ..	Kuia	„
„ father's brother ..	Koroua	„
„ „ sister ..	Kūīa	„
„ mother's mother ..	Kuia tuarua or tipuna tuarua(4)	„
„ „ father ..	Koroua tuarua or tipuna tuarua	„
Stepfather	Pāpā whakaangi ..	„
Mother's brother	Pāpā	„
„ sister	Whaea or kōkā ..	„
„ mother	Kūīa	„
„ father	Kŏrŏuā	„
„ mother's brother ..	Koroua	„
„ „ sister ..	Kuia	„
„ father's brother ..	Koroua	„
„ „ sister ..	Kuia	„
„ mother's mother ..	Kuia tuarua or tipuna tuarua	„
„ „ brother's son	Pāpā or matua kēkē ..	„
„ grandparents ..	tīpuna (tīpuna in plural)(5)	„
Stepmother	Whăeă whakaāngi ..	„
Stepchild	Tămăitī whakaāngi(6)	„
Stepbrother	No distinct term.	
Stepsister	„	
Children of father's elder brother	Tŭakăna	
Children of father's younger brother	Tăinā or tĕinā	
Children of father's elder sister	Tuakana	
Children of father's younger sister	Taina or teina (7) ..	„
Children of mother's elder brother or sister	Tuakana	
Children of mother's younger brother or sister	Taina or teina	
Son	Tăma (tamaiti = child)	„
Eldest son	Tama	„
Youngest child	Pōtĭkĭ	„
Son's wife..	Hŭnaonga	„

(4) *Tuarua* means "second." *Kuia taurua* = second grandmother—*i.e.*, great grandmother.

Tipuna is a variant form of *tipuna*.

(6) *Tamariki whakaangi* in plural.

Tuakana here denotes members of elder branch of family, *taina* those of younger branch, but the male speaker would call his female cousins here his *tuahine*, or sisters. The female speaker would term her male cousins *tungane*, or brothers.

SYSTEM OF MAORI NOMENCLATURE, CONSANGUINEOUS AND AFFINITATIVE—*continued.*

The Person spoken of. Degree of Consanguinity.	The Speaker.	
	Male. Term used.	Female. Term used.
Daughter	Tamahine (tamāhine in plural)	Same.
Eldest daughter	Tamāhine (among Tuhoe)	"
Daughter's husband ..	Hunaonga	"
Children of son or daughter ..	Mōkōpūnā	"
" brother's children	"	"
" sister's children ..	"	"
Brother's or sister's child ..	Tamaiti (tamariki in plural)	"
" eldest son	Tama	"
" youngest child	Potiki	"
Husband	..	Tāne.
Wife	Wāhīnē or hoa wahine(8).	
Brother's or sister's children's children	Mokopuna	Same.
Elder sister's husband ..	Tāokētē	Tuakana tāne.
Younger sister's husband ..	"	Taina tane.
Elder brother's wife ..	Tuakana wahine ..	Taokete.
Younger brother's wife ..	Taina wahine ..	"
Brother's or sister's son's wife	Hunaonga	Same.
Brother's or sister's daughter's husband	"	"
Husband's sister	..	Taokete.
Wife's brother	Taokete.	
Husband's elder brother ..	..	Tuakana tane.
" younger brother ..	..	Taina tane.
" parents	..	Hūngārēi or hūngāwai.
Wife's elder sister	Tuakana wahine ..	
" younger sister ..	Taina wahine ..	
" parents	Hūngārēi or hūngāwai	
Husband of wife's sister ..	Hoahoa.	
Wife of husband's brother ..	..	Hoahoa.
Male children of father's and mother's brothers and sisters	Tuakana or taina (see *ante*)	Tungane.
Female children of father's and mother's brothers and sisters	Tuahine (see *ante*)	Tuakana or taina.
Husband's child by former wife	..	Tamaiti whakaangi.
Foster-child	Tamaiti whangai ..	Same.

(8) *Wāhīnē* (in singular) = woman, female, wife. Becomes *wāhinē* in plural. *Hoa wahine* = female companion, literally.

Speaking generally, a native always speaks of his cousins —*i.e.*, the children of his father's and mother's brothers and sisters—as his "brothers" and "sisters." The terms *tuakana* and *taina*, given in the table, do not always imply that such persons are older than the speaker in years, but that they belong to an elder (*tuakana*) or younger (*taina*) branch of the family. Also, in speaking generally of the children of his brother or sister a native always calls them his "children."*

It will be noted in the above table that the term *pāpā*, meaning "father," is applied not only to the speaker's real father, but also to all brothers of his parents and to sons of his parent's uncles. The term *papara*, which denotes the speaker's real father, is not often heard, the generic term *papa* being much more common. The same remarks apply to the term *whaea* (mother), which is applied not only to the speaker's real mother, but also to sisters of his parents, and others. Also, the term *tuahine* has a wide application, it being applied by a male speaker to his cousins, and to daughters of his parents' cousins, &c. Thus, when you hear that a Maori has married his "sister" you must not take it literally, for she is probably a cousin several times removed. It behoves one to be careful, for it is very easy to make errors in Maori consanguinity.

These remarks on Maori nomenclature might be continued indefinitely, but must be kept for a separate paper. It will be seen, however, that, although some of the more generic terms, as those above quoted, have a wide meaning, yet terms of kinship among the Maori are much more copious and definite than such a system as the Hawaiian, as given by Letourneau in his chapter on "The Family in Polynesia." His information, however, may have been meagre.

There is no sign of polyandry among the Maori so far as my researches have extended. Close questioning of the old men leads one to the conclusion that monandry has been the custom of the people for many generations, probably centuries, or some trace or influence of the custom would probably be noted. The old-time historical traditions help to prove the monandrous conditions which obtained here and in other isles in times long passed away. Certainly there are a few, very few, isolated cases on record among the Tuhoe Tribe where, a married woman having committed adultery, it was agreed to by her people that she should have the two husbands. The evidence, even in these cases, is against a former polyandrous system.

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* *Taku tamaiti* = my child; *aku tamariki* = my children.

Polygamy and Monogamy.

Generally speaking, the Maori people were monogamous—that is to say, the bulk of the people married but one wife. But among the chieftain class polygamy obtained, and, indeed, may still be met with among the Tuhoe people. Polygamy does not appear to have obtained among the common people, but seems to have been a privilege of rank. In many cases a chief would take a slave wife in addition to his principal wife, who would be of his own people, and probably his equal in rank. Again, the taking of a second wife would sometimes be caused by the sterility of the first wife, and a desire to have children. I know of a case in which a half-caste, a successful business man, and living as a European, took a second wife for the above reason. This, of course, was a marriage *a la* Maori, and not an act of bigamy, as no marriage ceremony was performed.

At the present time one native here at Rua-tahuna has three wives, and several others have two each. In two of these cases the parties live together, with others, in large communal sleeping-houses, and appear to get on well together. In the third case the two wives live at different villages, and are not friendly with each other. The husband lives sometimes with one and sometimes with the other. Te Ika-poto, Tama-rehe, and Te Purewa, famous chiefs of this district in the last century, had each four wives.

The different wives of polygamous marriages appear to be kind to each other's children, but such kindness, albeit of a somewhat negative nature, is common among the natives.

Consanguineous polygamy obtained here. A man would sometimes marry two sisters, and sometimes a mother and daughter. The latter was a rare occurrence, but the former frequently occurred. The marriage of the deceased wife's sister was, and is still, common, while the marriage of a widow to the deceased husband's brother was an established, and, indeed, an ancient, custom. Two sisters would sometimes marry two brothers.

The first or head wife of a polygamous marriage is termed the *wahine matua*. *Wăhĭnĕ* = woman, female, wife; *matua* = first, important. Among the Ngati-Hau Tribe the remaining wives are termed *muri-manu*. *Muri* = after, subsequent time, behind; *manu* = bird. The wives in polygamous marriages term each other *hoahoa*. Cf. *hoa* = friend, companion, mate; *whakahoa* = to associate with. The *wahine matua*, or head wife, was not exempt from labour.

In polygamous marriages the first-born child would rank first and have the greatest authority of any of the children in matters connected with the land, &c., as well as in all other

ways, although such child might not be the son of the chief wife, but born of one of the *muri-manu*. All children of the several wives would inherit the property of the parents—*i.e.*, they would have a share in the land and in any personal property the parents might possess. The father would take the children with him on hunting, fishing, and bird-snaring expeditions, and thus they would be taught the land-boundaries, and would learn the location of snaring-trees, bird-troughs, &c. And in after-years the father would apportion such lands among his children, the first-born son probably receiving the largest share, if of a capable and influential personality. Hence it will be seen that the children of the principal wife did not necessarily take precedence over the others.

Incest.

We have already shown what marriages are deemed incestuous by the Maori. It is worthy of note that the rules in regard to marriage of relatives among the Maori nearly resemble our own. Such a system does not appear to be common among barbarous peoples.

Professor Westermarck has stated that the horror of incest is not an instructive sentiment (animals do not have it), but rather a social habit, springing from sexual repulsion for persons, even unrelated to the family, with whom one has been brought up from infancy.*

Andrew Lang, in his "Custom and Myth," quotes Morgan (of Primitive Sociology fame) as follows: "Primitive men very early discovered the evils of close interbreeding"; as also the latter's statement that "early man discovered that children of unsound constitutions were born of nearly related parents." Mr. Lang goes on to say, "Mr. Morgan supposes early man to have made a discovery (the evils of the marriage of near kin) which evades modern physiological science. Modern science has not determined that the marriages of kinsfolk are pernicious. Is it credible that savages should discover a fact which puzzles science?" Now, it may or may not be credible, but how is it that the Maori holds this view, viz.: that marriages of those closely related is followed by a *tipuheke* (degeneration, deterioration) in the offspring? For, as we have seen, the Maori are endogamous, and they have no totem system, for exogamy or totemism might have been taken as a cause for the Maori custom already given. Maine, author of "Early Law," regards exogamy merely as a prohibition of incest. The Maori idea may be summed up in the words of an ancient proverbial saying of the people, "*E moe i to tuahine, he itiiti*"—*i.e.*, "Marry your *tuahine* and the

* See Deniker's "Races of Man," chap. vii.

result will be puny offspring." *Tuahine* = sister; also used for cousins.

Tane, Tangotango, and Wai-nui were children of the primal parents, Rangi and Papa (Sky and Earth). Tane married his own daughter, while Tangotango (a male) married his sister Wai-nui, and this, according to Maori myth, was the origin of incest. Marriage also originated in those days of the misty past in the union of the strange beings who preceded man.

It does not appear that incest was common among the natives. It is given sometimes as an explanation of peculiarities in genealogies. To bring upon themselves the contempt of the tribe would be the result, and this would act as a deterrent, more especially among a communistic people such as the Maori.

Since the arrival of Europeans in this land the old native laws, rules, and customs have become much relaxed, and the change in many cases is for the worse. The social rules of the Maori suited such a people, and they do not grasp or adopt ours in a way for such to be beneficial to them. Intermarriages with Europeans do not as a rule produce a desirable cross. Half-castes are, physically, a fine people, though not long-lived as a rule. Mentally they are clever, quick, and sometimes attain distinction. But morally they are often below par, their code of ethics in many instances being an uncertain quantity. In one such family at least four members thereof have been guilty of incest, but it does not seem to trouble them in any way. A native couple who committed incest in this district were expelled from the tribe. A native of the Rotorua district cohabited with his own daughter. On it becoming known they fled together, but were pursued and caught. The girl was taken back home and the father was expelled.

Incest is, in this district, termed *irawaru*, *moe tuahine*, and *ngau whiore*, the expression *kai whiore* being a variant form of the latter. Three of these terms are connected with dogs. Irawaru is the name of a person in Maori mythology who was turned into a dog by the magic arts of Maui, and who was afterwards looked upon as the origin, or tutelary deity, or parent of dogs. *Ngau whiore* means "tail-biter." Those who commit incest are compared to a dog which turns and bites its own tail.

It will thus be seen that the Maori has very sensible notions on the subject of incest and consanguineous marriages. His ideas on such things resemble those of the most advanced peoples. He does not bar whole groups of slightly related peoples from intermarrying, as do so many barbarous and semi-civilised races.

Youthful Cohabiting.

There is a Maori saying, "*He iti kopua wai, ka he to manawa.*"* This saying is heard when a girl wants to marry too soon, before she is old enough, in the opinion of her elders. Early marriages seem to have been common among the Maori, although the elders appear to have believed it to be harmful, judging from such sayings as the one given above, and which were somewhat plentiful. The young folk early arrive at puberty—Colenso says from twelve, and even eleven, years upward. There was no system of obligatory defloration of girls, nor was it in any way necessary or practicable. The girls attended to that, for illicit intercourse was, and is still, common among the young people. It often happened, say the elderly people, that a girl would have intercourse with a youth before she arrived at puberty—"before the growth of hair," as a native puts it. Daughters of chiefs were probably looked after better than those of the common people, and those girls who were made *puhi* were *tapu* to all men until married. Girls who had been with young men were sometimes detected by traces of *parapara*, &c., being found upon them.

In former times many girls married, or were married, very young, even sometimes before puberty and before the commencement of menstruation—at least, so say these natives. A young girl of this district was lately married and she cannot have been more than thirteen, or at the most fourteen, years of age. This is, however, unusual here. The term *kōpĕpĕ* is here used to denote this marrying of very young girls: "*E tama ! He kopepe koe i te tamaiti na.*"

Several causes may be assigned for the early marriages of the Maori—the early age of puberty; the carrying-out of the *taumou*, or infant betrothals; the keen sexual desire of girls, not repressed or controlled by long generations of self-control and moral teachings of elders, as among more advanced peoples. Possibly it was as well so, for, youthful cohabiting being common, and a prolonged course of general intercourse being conducive to sterility in the female, it were better for the girl to be married to one man. For her days of freedom in sexual matters would then be over. Adultery spelled trouble in the days of yore.

An old native saying has it thus: "*Korerotia ki runga ki te takapau whara-nui,*" the meaning of which is, "Let matters be properly arranged by the elders in council. Do not let the young people cohabit promiscuously, but let the tribe marry them according to proper rules and older custom."

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* Applied to the girl: "A small pool of water will exhaust a man's breath if he immerses himself therein."

The term *whaiaipo*, meaning sweetheart or lover, is applied to both male and female persons, single or married. It is not, however, applied to any one *as* a married person, but only to those who have a lover other than the husband or wife, and to that lover himself or herself. Hence it may describe the sweetheart of an unmarried person or the lover of an adulterous wife or husband. Another term having a similar meaning, and said to be a more ancient expression, is *whakaaweawe*, while a *kai-whakaaweawe* is a go-between, a person who acts as a messenger between two lovers. The etymology of the term *whaiaipo* is significant.

There was no cult among the Maori that required the prostitution of girls before marriage, as those of Aphrodite and Mylitta. Neither was there any prostitute class among them. The young people, when gathered together at night in the *whare tapere*, or "play-houses," in which many games, dances, &c., were indulged in to pass away the time, would make advances to each other and afterwards meet at some place agreed upon. Such places were often in the forest, and were termed *taupunipuni*. These advances spoken of were often made by the girls, the recognised sign being a pinch, or the scratching of the finger-tip on the hand of the desired person.

Puhi.

The *puhi* custom among the natives was a singular one, and deserves mention here. Williams's Dictionary gives the following meanings of *puhi:* (1) A betrothed woman; (2) a much-courted unbetrothed young woman. Neither of these definitions appears to describe the *puhi* among the Tuhoe Tribe. A betrothal here is termed *taumou*,* of which more anon. A *puhi* among Tuhoe was a girl of good family, first-born daughter of a chief, who was rendered *tapu—i.e.*, she was not allowed to have sexual connection with any man, nor to perform any work except such as the weaving of the better-class garments, as *korowai, aronui, kahu-kura, maro kopua*, &c., which work was equivalent to the "fancy work" of ladies among us, a light and genteel employment. She would have some attendant to cook for her, and was under restriction in many ways. These *puhi* were not allowed to marry, or, at least, such was often the expressed intention, though they might fall from grace in after-years when tired of single life. The idea was to make her an important person —"*Ka whakapuhitia hai wahine rangatira*"—in the tribe, a lady of rank, to be treated with respect and looked up to. If a *puhi* were detected in illicit intercourse with any man she

* *Taumou* was the name of the function or custom; the girl was not termed a *taumou*.

was degraded and the *tapu* taken off her. No girl of the common people could be a *puhi*, nor yet a younger daughter, but only the *tapairu* (first-born daughter of a chief's family). The *puhi* was a renowned personage (*he wahine ingoa nui*), for such was the object of the custom. Hine-i-turama was a famous *puhi* until she fell from grace. She fled to the forest and there gave birth to a child (afterwards known as Tu-wairua). A search-party found her by hearing her singing a lullaby over her child in the depths of the forest. Huinga-o-te-ao, of the ancient Maruiwi, was a famous *puhi*, she who died the tragic death near O-hiwa. Nahau was another renowned *puhi*, so *tapu* that she could do nothing for herself, hence the saying, "*E noho ra, E Nahau ! Tena te ia o Rangi-taiki hai kawe i a koe.*"

The following song, termed a *Waiata mate kanehe*, was composed by a *puhi* of days gone by who had fallen in love with a man named Kau-i-te-rangi. She thus addresses him :—

Tera te waka i a Kau-i-te-rangi—e
Kapokapo ana mai me he rau harakeke.
Tera, E Pa ! Ka makamaka i o rimu
Kia hemo ake ai nga tapu i ahau
Kapo ana koe ko te whakahoro e roto
Oma ana ki matenga
Kia patua i roto Tuhapari e te ika
E ta te moari, e te tau—e
Tuakina a Piha, ka whiu ki te pari.

Courtship, "Atahu," Arranging of Marriage.

A good deal of formality pertained to the arrangement of a marriage. When a young man wished to marry a certain girl he would usually inform his elders of his wish. A meeting of the village community, usually a sub-*hapu* or family group, would then be held, and the matter would be discussed at length, each person who wished to make any remarks rising to address the meeting, both men and women taking part in the discussion and arrangements. The girl would be asked before all the assembled people as to whether she was agreeable or not. The matter would not be ended with the consent of the girl, her parents, and near relatives. The tribe would take part in the matter and have their say, often making objections on some ground or other, as in the case, already quoted, of Rangi and Hapine. Sometimes when they expect opposition a young couple will take to the woods and remain there for some time, until the matter is arranged or they are discovered and the girl taken away.

There is, of course, much more formality in arranging a marriage between persons of the chieftain class than is the case among the common people, marriage having its origin as

a social custom, so far as rites and rules are concerned, and not as the result of a national religion or theological system. Marriage among the low-born people, the common people, of the tribe was ever an event unmarked by rite or invocation such as pertained to marriage among the chieftain class.

When a young girl wished to marry a certain man she would possibly have intercourse with him before informing her elders of her wish. But, still, if she was of good family she was thought more of if she went to her elders first and said, "I desire So-and-so." If they considered him an undesirable person they might say, "He is a *tutua* (of low birth). Do not have him, but marry So-and-so, who is of good birth, although ill-favoured"; and the girl would probably do as they bid her. Even now it is a common thing when a marriage occurs to hear the remark made, "The tribe married them." The old-time habits and customs of a communistic people die hard.

The young unmarried girls of the present time are decidedly unchaste, more especially those living in the larger settlements, where the young people are thrown together a good deal. Adultery is of rather frequent occurrence in this district, and generally seems to be detected. For some reason the natives do not seem to be able to keep a secret well. In adultery, as in other matters, one of the persons usually mentions or admits the matter.

A considerable number of native women have married Europeans, and many of these women, it must be said, lead most exemplary lives, for many are clean, industrious, and evidently desirous of living as Europeans do. They are often prolific to a white man, families of six and seven being not infrequently met with. They take a pride in being able to cook European articles of food, such as are not used among the natives, and are a great improvement on the native woman as seen in the Maori villages.

As observed, the Maori of old had a clear perception of the desirability of arranging marriages in due orthodox form, or, as he terms it, *He mea ata whakarite* (a matter carefully arranged), this remark, however, applying principally to the *rangatira* or chieftain class.

In the days of yore when a man desired a woman who disliked or was afraid of him he would hie him to the village priest and enlist his services. The priest (*tohunga*) would take some substance, *hōrū* (red ochre) being often used for this purpose, which he would proceed to render efficient as a sort of love philtre. This he did by uttering over it a charm which comes under the generic term of *hoa* (*ka hoaina e ia taua mea*). He then hands the article to the man, who takes it away with him. He must not turn aside on his way back,

nor yet partake of food, but proceed direct to where the desired woman happens to be. Even if she were in a cooking-shed preparing food he would go straight to her and cram the substance into her mouth. That is sufficient. Even though she spits it out, yet the charm will be effective and she will come to him, her dislike will be overcome.

The expression *whakawherewhere* is applied to conciliation of a desired woman by means of gifts. A man will give or send to a woman some present which he hopes will cause her to like and desire him. The term *aruaru* signifies "to chase" and "to woo," while *mātŏrŏ* means "to woo, pay addresses to."

The custom known as *kai tamāhine* was a singular one. A party of young, active, and presentable men would form themselves into a party and go on a visit to some village where resided a young woman noted for her good looks and qualities. The visit was for the express purpose of showing themselves and their accomplishments to the girl, in the hope that she would accept one of them as a husband. The period of the visit would be quite a gay time, for the party of young men would give performances of various kinds, in order to exhibit their skill, grace, dexterity, and so forth, each endeavouring to excel his companions. They would perform *haka*, or posture dances, of various kinds, and play games of skill. Each would hope that the girl would select himself as a husband.

The term *kai tamahine* is a peculiar one. *Kai* signifies "to eat, to bite," also "food." *Tamahine* = daughter. According to Letourneau, when a Kabyle father has married his daughter the phrase in ordinary use is, "He has eaten his daughter." Among that strange people girls were sold by the father or other relative.

The term *ringa hoea* (rejected hand) is used among some tribes to denote a rejected suitor. Such a rebuff would sómetimes cause the disappointed man to have recourse to magic. He would make use of a magic charm or spell (*karakia makutu*) known as *papaki*. This had the effect of killing the hapless woman—so, at least, my informants tell me, and who am I that I should doubt the word of these sages!

In the Legend of Paoa we read that when that old-time wanderer was on his travels he remained at a certain village for some time as a guest. The daughter of his host fell in love with him, and, coming to his side one night, she scratched his hand as a sign of her desire for him. She had already spoken to her parents about the matter and they had consented to her marrying him.

There was a sort of love charm, termed *atahu* or *iri*, which was formerly much used in order to cause a person of

the opposite sex to entertain affection for the operator. It was also used to influence an absent lover, wife, or husband, and to cause such to return to the lone one. In conjunction with the *atahu* obtained a singular custom of sending a bird, the *miromiro*, to carry the love and desire of the operator to the distant woman, wife, or husband. If the rite was properly performed it would cause a woman to come to her lover however distant he might be, or however much her friends might try to prevent her from going. The *atahu* or *iri* is a *karakia* (charm, spell, ritual, invocation, incantation) to cause a person of the opposite sex to love the repeater. When Tamatea-rehe, of the Children of Awa, saw first his (future) wife, Manawa, he was much struck by her, and this feeling increased so that eventually he despatched a *miromiro* bird to convey his love to that dark-skinned maid. At the same time he utilised the following *iri* in order to influence the affections of Manawa, and to "bind" her to himself. It is also termed a *karakia whakapiri*, a "fastening charm":—

Iri kura, iri kura
Iria te tupua
Tupua nuku
Te whakamaua mai Manawa
Ki toku tinana
Whiti ora a te tahito
Hotu nuku, hotu rangi
Tukia te papa i raro i a Manawa
Te pukenga, te wananga
Whakamaua ki tahito o te rangi
Iri toro, iri toro
He—i.

The following *atahu* was given by a member of the Ngatiraukawa Tribe. He says, "This is an *atahu* used to cause a woman to desire a man or a man to desire a woman. When the shades of evening fall the *tohunga* (priest) goes to the waterside and, having used the water in ancient form, he performs the *atahu* rite, repeating the following charm:—

"Tu te urunga, hau te urunga
Maniania te moenga
Hakune atu te po, hakune atu te ao
Ko tou aroaro i tahuri mai ki ahau
Ko toku aroaro i tahuri atu ki a koe
He miromiro taku manu ka tukua atu
Hei hiki mai i a koe, E te ipo.

The applicant gives to the priest some article, such as a garment (in modern times often a pipe), in order to give *mana* (power, prestige, or effectiveness) to the rite." The expression *ipo* here used is equivalent to a term of endearment. It means "pertaining to love": *He waiata ipo* = a love-song. The two last lines render thus: "My bird sent is a *miromiro*, to bring you hither, O love!"

Practically all rites performed by the priest of old were executed either at a sacred fire or by the waterside, and nearly always at dawn or dusk, not in the day-time.

An old warlock of Awa discourseth upon the *atahu*, "The *miromiro* is a bird employed in the *atahu wahine*. Should a man desire a certain woman, although she might be a member of a different tribe, yet will he obtain her. Though her home be afar off he will obtain her. He despatches a *miromiro* bird to fetch her. He notes carefully the wind. If it is blowing in the direction of the home of the woman he desires he then takes a feather, being careful to seize it with his left hand, and passes it under his left thigh, after which, holding the feather upright in his advanced left hand, he recites the following charm :—

"Hau nui ana ra
Ko te hau—e
Te kura i te ipo—e
To ara mai, E te ipo
Haere ki roto i a koe mihi ai
Waha mai te ipo, E te hau—e
Tutakina iho ki au—e
Whiwhia mai, rawea mai
Toro hei.

He then tosses the feather into the air for the wind to carry. (In the charm he calls upon the wind to bear his love to him.) Before long she will have arrived."

Regarding the passing of the feather under the left thigh: When a priest proceeded to *takahi* a wounded person, and recite a charm to heal his wound, it was always the left foot that he placed upon his patient, for that is the *tapu* foot. It is the *manea* of that foot that gives force, virtue, effectiveness to the rite and charm. The *manea* is the *hau* of the human foot or footstep, a sacred or supernatural power, essence, or quality, which has great influence in preserving human life, &c.

When in olden times a young man of the Tuhoe Tribe went through the operation of being tattooed the following *atahu* was repeated over him by the priest, in order to cause women to admire and like him :—

Taku tamaiti i wehea e au ki te rangi
Ka piri, ka tata
Ka huakina mai Tangaroa—e
Whakina mai ko ou Hine-tuakirikiri
Ko ou Hine-tuarourou
Mai te ruwha, mai te ruwha
Mai te aroha, mai te aroha
Mai te aroha ra koe—e.

Here follows another *atahu* of the Tuhoe Tribe :—

Takoto ra, E hine!
I to urunga, i to moenga
Iri kura, iri kura, iri toro
Ka whana atu koe i reira

Kia rokohanga mai e koe
Nga tai tu o te akau—e
Ka whana atu koe
Kia rokohanga atu e koe
Nga tai ka tanumi
No Rarotonga—e
Tirotiro ko rangi ki te whetu
Whakataha to mata ki te marama
Whakataha to mata ki te marama
Au nei he motu puhi rakau
Whakina te tau kia rangona
Mokimoki te kakara kia iria—e
Na to ngakau koe i hua kia mahia tiori
Na to matua koe i hua kia mahia tiori
Tu ana a ia ki te rangi, mihi konaki ai
Te ipo e ki te moenga
E tangi ana ra te korori
E tangi ana ra te korora
Taku hei mapuna
Kua riro titapu
Kou te ruru, kou te ruru!
Kou!

And here is another :—

Pu mauri kura
I whanake i te tara o Maninihau—e
Ki horo mai ra tonga
Ka pukea au e te wai—e
Maua ko te aroha
I roto wahine atu ra—e
Tuarua rawa mai ki te moenga
He ringa ta auta rawa ake
Ka ea kai te moenga—e
E tangi ana ra te korori, te korora
Taku hei mapuna
Kua riro titapu—e
Kou te ruru, kou te ruru!
Kou!

The following so-called *atahu* is a modern one, as will be seen by the English words occurring therein. Nor is it a charm for general use, as are the foregoing. It was composed by a woman named Matua-kore, whose husband had deserted her, in order to express her feelings. She evinces a desire to have recourse to the *atahu*, but is doubtful as to its efficacy :—

Homai noa nei e te *hāhi*, e te runanga
He kupu hai whaka*papaahi*
Mo te ngakau o *Kuini* whaihanga
Tenei to *paipa* me kawe atu ki a Te Reretautau
Hai iri atu, hai atahu kia hoki mai ai
Nohea e hoki mai
Ka tini, ka mano nga puke
Kai waenga ko Tauaki, ko Takamai
I o Apa ripa tauarai ki o Te Ao
Ki a Te Manihi te aroha nei au
Haere ra, E Ura E!
Korua ko to kakau whakawhana

Waiho au i konei aue kau ai
Aue, te tane ra!
Aue, te tane!
Tee ko mai i te wai para hoanga ki waho
Aue, te ai—e!
Ka whiti nei au kai Rurima, kai Mautoki
Kai Karewa, te motu o te kuia
Ka eke nei au te puke huia
Kai Ruahine au ka taru mate
Ka hinga au ki te whare—i.

The following illustration and imaginary conversation was given by a native in explanation of the *atahu* and sending of the *miromiro:* "A man comes to the priest. He says, 'I have come to you because a man has run away with my wife.' It is asked, 'What shall be done?' And replied to, 'Do you arrange it as according to ancient custom.' Very well. When the sun sets, then the *miromiro* bird will be despatched in order to bring back the woman who has been cajoled and carried off by a man. Although she may be in a house when the bird arrives it will go inside and perch upon her head. Then swiftly the woman returns, like the wind which blows beneath her feet. Ere long she has arrived. This was a very effective rite of the Maori."

The following modern instance of an *atahu* was related to me by a Whakatane native, who seemed to believe it (the charm recited has already been given): Himiona, a native now living at Whakatane with his wife Kumara, had left her some years previously in order to visit friends at Poverty Bay. While at the latter place he became attached to a native woman there, and they lived together as man and wife. Kumara heard of this, and at once went to Rangi-taiki in order to consult one Riperata, an old wise woman of that place. She was told by the latter to return in the evening. She did so, and was conducted by Riperata to a stream, who also made her divest herself of her clothing, when the aged one sprinkled her with water and repeated the *atahu* charm over her. Riperata said, "I can see the *wairua* (spirit) of your husband standing by your side. Return now to your home; in a week your husband will return to you. When he arrives and greets you do not *tangi** (cry) over him, but both of you go to the water and immerse yourselves therein." This immersion in water was to cleanse the twain from the *tapu* of the rite performed. Riperata then despatched a bird, the *miromiro*, to bring back the errant husband. The bird flew to the East Coast, and to the village where Himiona was living with his new wife. The couple were seated among others in a house at the time. The bird entered the house and alighted upon the head of Himiona. At once he was

* Friends are welcomed by prolonged weeping among the Maori.

seized with a desire for his first wife; his love for her returned. He rose and started to return to Whakatane, a journey of some days. His companions could not persuade him to remain; nor could they catch the bird, which went its way.

It sometimes occurred that the people of a family group or clan would resolve to demand a girl of another village community as a wife for one of their young men. A party of them would proceed to the place and demand the girl for that purpose. If a single woman, she might be handed over without any trouble occurring, provided that she was agreeable to marry the young man. If not she would be held and protected by her people. Sometimes a very stormy scene would follow, as each party strove to gain possession of the girl, who would be seized by the opposing parties, and who sometimes suffered severely at their hands. Even fatal consequences would at times attend these wild scenes. Or, on arrival at the residence of the girl, the party might seize her at once, in which case trouble would be likely to quickly ensue, and the two parties be transformed into a seething mass of excited, yelling beings, resembling maniacs. Scenes of violent abduction were by no means rare in Maoriland. And yet woman occupied among the Maori people a much better position than she occupied among most barbarous races. She was usually upheld by her people when she objected to marry a certain man who had desired or been selected for her. She was to a considerable extent independent, and had a voice in matters affecting the tribe. It was, perhaps, in connection with adultery that her status appeared lowest, for she was then regarded apparently as property, and any one tampering with her must needs pay for meddling with another person's property.

As already observed, many statements have been made by writers that the Maori had no marriage rite, but that a couple simply agreed to live together, and that was all there was about it. But if a marriage between two young people was not *he mea ata whakarite* (a matter deliberately arranged) by their elders, or by the tribe or sub-tribe, then such a union was much looked down upon and condemned. If the recognised and established usages were not respected and followed, but the union a mere *moe noa iho*, or random cohabiting, then a child born to such would be termed a *poriro* (bastard), a *moenga hau, he mea kite ki te take rakau*, a thing found under a tree.

In speaking or writing of the customs of other peoples, more especially those of the more primitive races, we are much too apt to set up as a standard of propriety, &c., our own rites or customs, and if those of the people under discussion do not coincide with our own, then they are condemned

as improper, inadequate, or ridiculous, or statements are made that no such customs exist among such people. These things are wearying beyond measure.

The Maori marriage system was a very good one for a people living in the culture stage which obtained in Polynesia. It was considerably in advance of the systems of many peoples who in general culture occupied a higher plane.

In the arranging of a marriage it is not only the families of the young couple who take part in such, but also the family group, or the *hapu*, or perhaps even the whole tribe—*i.e.*, in a marriage of important persons. Indeed, the parents often have little to say in regard to the marriages of their children, the leading part in the arrangements being taken by the brothers and sisters of the parents. The Maori likes to obtain for a son-in-law an industrious man (*ihu-puku* or *ihu-oneone*).

Taumou (Betrothal).

The term *taumou* (of which *taumau* is a variant form) is applied to the custom of the betrothal of young people which obtained in Maoriland. This custom was also known as *whăkăpākūwhā*. The little couple so betrothed, or promised, by their elders would be described as *he mea karangaranga*. Observe the etymology of the second term above: *Whaka* is a causative prefix; *pa* = to touch, come into contact with; *kūwhā* = the thighs.

It is probable that the *taumou* was practised only among the people of good birth, and not by the common people. This is the method which the evolution of marriage rites appears to take: First, the cohabitation of man and woman, as among savages, devoid of ceremony or ritual; abduction, often forcible, of the woman. Then as a laic institution, a social arrangement, often followed by the purchase of the woman. In both of these stages the woman is treated as a being much inferior to man; she represents so much property, and can be punished, ill treated, or disposed of in any way which the husband sees fit to adopt. These modes are the *usus* and *coemptio* of ancient Rome. The third stage, as the Roman *confarreatio*, in which we see the adoption of a ritual, crude at first, but afterwards becoming more ceremonious as the people advance in culture. Note a passage in Letourneau's "Evolution of Marriage": "We must note that at Rome, as in Greece, the religious ceremony was in no way essential to the marriage, which was a laic and civil institution in the first place." Quite so, for only the upper classes had this ceremony performed at their marriages, hence is it termed the "aristocratic marriage."

Now, the Maori was in this third stage of marriage-evolution. He was adopting, or adapting, ritual to his old-time

system. But it was essentially an aristocratic rite, for only those of high birth had the ceremony performed at their marriage; the common people were not deemed worthy of the priestly invocations or the *umu kotore*. They were dogs.

We return to our *taumou*. This was not a universal custom among the chieftain class; every girl or boy of good birth was not so betrothed. It was sometimes done for political reasons, in order to advance the welfare of the clan or tribe. These betrothals took place during the infancy of the couple. For instance, a man while visiting a village community might chance to see a little girl who took his fancy, and whom he would desire to pre-empt, as it were, as a wife for his own little son when they should have arrived at marrying age. If the girl was of equal rank to his son he would claim her by making some such remark as, "*Maku tonu koe, mo taku tamaiti*" ("You are for me, for my child"). And that remark would be agreed to by the elders of the girl, unless they had some special objection to him or to the proposed alliance. It would then be arranged that the two children should be married when they grew up. It would be very bad form for any person to disregard the betrothal. Should any man have sexual connection with the girl he would very probably be slain, if a commoner, and possibly cooked and eaten; for the saying of old was, "*Kua eke he taumou na tetahi, kauaka hai raweke*" ("Those on whom a *taumou* has been placed, do not interfere with them").

After the betrothal the girl might be kept at home with her parents, or they might let her future father-in-law take her away to live at his place, and there to associate and grow up with her future husband; or she might stay alternately at each place. This custom, like many other strange ones, has long died out. The coming of the Europeans changed all these things, hence we use the past tense in describing them. Old Hauraki and his wife, of Rua-tahuna, are two of the few survivors of the last who were *taumou*.

A girl or boy who happened to be so betrothed was not termed a *taumou*: that expression simply implies the custom. A betrothed girl was not termed a *puhi* among the Tuhoe Tribe.

An old woman, a resident of Rua-tahuna, was betrothed during her childhood, when she was about seven or eight years of age, to one Tarei, of Ngati-Awa. After some time her aunt took her to the home of Tarei's parents, that the two children might be together. The girl remained there for some time, but did not like the idea of marrying Tarei, so her people took her back home, three days' march inland. No attempt was made by either side to coerce her. But when, subsequently, a party of Ngati-Awa visited Rua-tahuna they

made things interesting for her and her friends—but that is another story, which you will find at page 94 of Volume xxxiv. of the "Transactions of the New Zealand Institute."

The Umu Kotore.

The *umu kotore* was the marriage feast of the Maori—that is to say, of the aristocratic marriage before mentioned. It was at this function that certain invocations were repeated by the priest over the couple.

In the first place, the priest repeats a prayer or invocation over the twain to preserve them in health and prosperity, to ward off from them all evil, physical or otherwise. After this the pair enjoyed the rights of married people. The marriage feast is then prepared, and is known as *umu kotore*, or *kai kotore*. Probably the former term is more correctly applied to the ritual pertaining to this function and the latter expression to the actual food. *Umu* means a steam-oven, in which food was prepared by the neolithic Maori; but the term is also used to denote a rite as performed by a priest—*e.g.*, *umu pongipongi* = a magic rite to destroy man. *Kotore* means "the lower end, buttocks, anus, tail of a bird." The word *reperepe* (and *tareperepe*) also means the buttocks, hence the above feast is sometimes termed *kai reperepe* (*kai* = food).

I asked an old man why the word *kotore* is applied to a marriage. His answer was brief and convincing, "*Ko te take i kiia ai he kai kotore, i moe ko tona kotore i te tane ra. Ehara i te mea i moe ko tona mahunga*" ("The reason of the feast being called a *kai kotore* is because the woman's *kotore* married the husband. It was not her head that married (slept or cohabited with) him").

The *kai kotore* is special food, the best procurable, cooked in a separate oven (*umu kotore*) for the relatives of the young wife. Food was cooked in other ovens for the rest of the assembled people. Only the relatives of the young wife partook of the *kai kotore*, or *kai reperepe*, cooked in the *umu kotore*. The young couple themselves did not eat of the *kai kotore*. In some cases the wife's younger sisters would decline to eat of the food prepared in the *umu kotore*, *koi purua—i.e.*, lest they be *pukupa*, or barren.

Further invocations were repeated by the priest at the *umu kotore* which constituted a part of the marriage ritual, and gave *mana* (efficacy, power, prestige) to the ceremony. Another invocation, known as the *ohaoha*, was then repeated over the couple. This was equivalent to a blessing—in the first place, that the twain might not be assailed by sickness or the shafts of magic, but be preserved in health. It also invoked a state of fruitfulness for the wife, that she might bear children. In the event of the wife being nervous, or afraid of her

husband, an invocation known as a *whakapiri* was repeated over her by the priest, in order to cause her to cleave to her husband, to bind them together (literally, to "fasten" them together). This was performed at the above ceremony, lest they become separated.

The bulk of the assembled people had their food separate from the party who partook of the *kai kotore*, and the food prepared for the former was not termed *kai kotore*. The *mātāmua*, or first-born son of the interested families, would not partake of the *kai kotore*.

On my asking an old man of the Ngati-Awa Tribe as to whether or not his ancestors had these invocations repeated at the marriages of their important people, he replied, "Yes, it is quite true about the marriage invocations of former days. O, friend! the best invocation to use for a woman nowadays is money. If a man has acquired plenty of money he will acquire a wife easily enough. That is the proper invocation. The moneyed man gets a wife." Which was, methinks, not bad for the neolithic Maori.

Pākūwhā.

We will now give some description of the custom of *pakuwha*, which may be defined as a formal handing-over of the woman to her husband. It was a universal custom apparently.* The young couple may or may not have gone through the ritual of the aristocratic marriage. The term *pakuwha* is applied to relations by marriage, and also to the ceremony of handing over or delivering the wife to her husband and his people, for, as usual among the Maori, the husband had little or nothing to say during the function, his relatives doing all the speechmaking on his side of the house.

The *pakuwha* was made the occasion of a sort of marriage *hakari*, or feast. It was, and still is, quite an important item in the social life of the Maori. These meetings served to break the monotony of the lives of the people, and they thoroughly enjoyed them. Marriage and death are two important causes of these social functions, and the Maori enjoys *both*.

The *pakuwha* often takes place after the couple have been married, or have cohabited and arrangements concerning the marriage (see *ante*) have, of course, been completed.

"I am living, say, at Rua-tahuna. My daughter marries, or is to marry, a man from Te Whaiti, a day's journey distant. I and my relatives form a party and escort my daughter to her husband's home at Te Whaiti. We have been invited to do so by the elders of my son-in-law, who live at that place.

* *I.e.*, among the *rangatira* class, not among low-born people.

In some cases they would build a special house for this event. Such house is termed a *whare pakuwha*, but would receive a special name also, and be kept closed and unused until my party, the *ope pakuwha*, arrive there, when we take up our quarters in it. The *tapu* pertaining to all new houses of importance remains upon it until our arrival, when it is removed and the house rendered *noa* (common, free from *tapu*) by the priest of my party. Such a house would be built only when the parties are of high birth. In special cases it may be an elaborately carved house, in others a plain one having no embellishments of that kind, and in yet others it is merely a temporary house. The house is for the entertainment of the *pakuwha* party (*ope pakuwha*)."

(Sometimes the husband and wife go together to this function along with her relatives, and at others the relatives of the girl escort her to the home of the young man, where she is formally handed over to be his wife. Which amounts to this: that the *pakuwha* feast may be held either at the time of the marriage, or, in other cases, same time after the couple have been cohabiting. But always the first feast or entertainment (the *whare tiatahi*, or "first house," as natives term it, in allusion to the building of the special house) is given by the man's relatives, never by the woman's. The latter it is who give the second feast, or *whakahoki pakuwha*).

"Those Te Whaiti people have been busy collecting and preparing food for us. The realms of Tane and of Tangaroa have been called upon to furnish food-supplies for many months. Potted birds, dried fish, and divers vegetable products are ready in large quantities. Fuel is piled up in *apaapa* around the cooking-sheds, and parties of young people roam the forests for such woods as burn brightly without emitting much smoke. This is for the purpose of warming and lighting the houses at night, such fires being probably supplemented by crude lamps burning fat obtained from birds. There will be much talking in these houses at night, many speeches delivered by eloquent speakers, and much posture dancing.

"We send word to Te Whaiti by messenger as to the day of our arrival at that place. We time our arrival there so as not to arrive late in the day, even if it is necessary to encamp for the night within a short distance of the village of our hosts. When we march into the village we do so in close column and with a slow regular movement, albeit we do not keep step, as do the white men in their marching. Our column advances in silence, and each person thereof looks to his front, apparently unconscious of the noisy welcome of the village.

"As we march into the *marae*, or plaza, we see that the village people are drawn up in a mass by the side of the new house, the *whare pakuwha* (not in front of it), where they are crying us welcome; and in advance of them are some of the old women, standing singly out in the *marae* or mounted on shed-roofs or on the defences of the village, where each cries loudly in the doleful tones of the Maori a welcome to our party. And each of them is waving a cloak or shoulder-cape, waving us forward to our destination. This is the *tawhiri*, or *powhiri*. It is the welcome of the Maori people, even from the days of our ancestors.

"Slowly we march forward until we are opposite the column of the village people, and then we halt, with perhaps a space of fifty yards separating us. The wild welcome of our hosts still rings out, but no sound comes from our party. We do not *tangi** unless some misfortune has lately afflicted one of the parties, or my son-in-law has been long absent from his people. At such a meeting there is no general *hongi* (the native salute by pressing noses together). The priest of our party alone might so salute a few of the village people in that manner.

"The next thing done is the *rahiri whare—i.e.*, the lifting of the *tapu* from the *whare pakuwha*. This is performed by the priest of our party, who mounts the roof of the house and, standing on the ridge-pole thereof, recites the invocation known as a *kawa whare*. This was an important rite to the Maori of former days, but we will not go into that matter now, it is too long. Leave it for the days that lie before.

"The house is now free from *tapu* and may be used. Our party enter and rest therein. Then, one after another, the leading men of the village come and make speeches to us. The speaker does not enter the house; he walks back and forth in the front thereof as he delivers his speech, for this is the ancient custom of the Maori. The speeches made are a welcome to us—first to my daughter, who has married into this clan, and also to us, her elders and relatives. The leading remarks of all these speeches are a welcome to the young wife, as, '*Haere mai taku taonga*,' &c. ('Welcome, my treasure,' and so forth). When the speeches of the village people are over, then one of our party will go forth from the house and make a speech, returning the greetings of the other party. But all remarks centre round and upon the young couple. After the first speaker finishes and retires to the house another goes forth to have his say, and so on, until all who wish to speak have done so.

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* *Tangi* = to wail for the dead, or as an affectionate salute to long-absent friends.

"Then a procession of people of the village appears on the scene, each bearing a basket of cooked food, and all singing a weird song as they slowly advance. They place the baskets in a row before the *whare pakuwha* and retire. Then our party leave the house and, seating themselves before the food, proceed to satisfy their hunger.

"In addition to the above cooked food given to our party, there is also a supply of food presented to us, and which we can either use during our stay at Te Whaiti or take home with us when we return. This food is brought into the house in baskets, &c., and placed before us. The interior of the house is now quite free from *tapu*, the bringing of this food into it is the last act of the *whakanoa*, or freeing from *tapu*. This latter supply of food is often termed *kai kotore*, and is for the relatives of the young wife. It is composed of the best sorts of food, such as preserved birds. On the following day a large heap of food is stacked up in the *marae* and presented to our party. This is termed a *tahuaroa*.

"After the *kai kotore* is brought in the village people then carry in their presents of clothing, fine cloaks, capes, aprons, as also greenstone and shark's-tooth ornaments, &c.; and, in modern times, horses also, which, however, are left outside. These are placed in front of the young couple, who are seated together. Probably no formal or lengthy speech is made; each person bearing a gift lays it down, outspread if a garment, saying, '*Tenei te taonga ki a koe.*' For these gifts are to the husband.

"When these gifts are all presented the young husband rises and presents them all to his wife's people, to myself and relatives, who have escorted him and his wife from Rua-tahuna to this place. He keeps none of the gifts for himself, nor yet any for his wife. If he did so he would be considered an ignorant, low-bred sort of fellow. *Kāti ki a raua ko te mānā*—the prestige of the thing is enough for them.

"Sometimes at these functions a *turanga-a-tohu* would be performed, usually the day after the arrival of the visitors. This is a kind of war-dance, but simply given as an exhibition.

"Our party would stay a few days at Te Whaiti as the guests of my son-in-law's people, or possibly a week. Probably the young couple would stay there for some time, possibly until the return feast came off at Rua-tahuna, when they would, of course, attend that, and perhaps settle down there.

"The return feast mentioned is known as a *whakahoki pakuwha*. We, the relatives of the young wife, give this feast to my son-in-law's people. A special house might or might not be built by us for the event, and the description already

given will apply to this function. We make presents to our guests as they did to us."

The above is a description of the *pakuwha* as it obtained in Tuhoeland, and still does, with the exception of several items, as the *rahiri whare* and *turanga-a-tohu*. This custom was not carried out with low-born people. Also, the elders of the husband would probably decline to give a feast and gifts to, and entertain, the relatives of the wife if she was known as a *kai-rau* (fornicator).

When the son of Te Purewa married a Turanga woman the house built for the *pakuwha*, near Gisborne, was a temporary one, but it was a gift to the guests, and a valuable one; for it was a long house, and the walls thereof were composed of calico print, while the roof was covered with new blankets.

Some time ago Paora, of Tuhoe, married a Ngati-Raukawa woman here at Rua-tahuna. They lived here about two years, and then went, accompanied by some of Paora's relatives, to the wife's people. The young couple lived there about a year, then they returned to Rua-tahuna, escorted by some of Ngati-Raukawa, who were entertained here by Paora's relatives. This latter was a *whakahoki pakuwha*. The couple have since returned to the wife's home, where they are now living.

The expression *ta pakuwha* is applied to affinitative relatives—*i.e.*, relatives by marriage. A company of related people travelling together to visit the parents-in-law of one of their number is so termed. (Compare *ta tataeto* = a flock of whiteheads—a bird.) It appears to be applied only to a company of persons. A couple visiting their son-in-law would be termed simply *pakuwha*.

Kaupapa pakuwha: "Suppose I marry your daughter. I select a greenstone weapon or ornament or a fine cloak and present it to you (my father-in-law) as a *kaupapa pakuwha*. Hence we hear such questions as, 'Where are the *kaupapa* of the *pakuwha?*'" Then such gifts are exhibited for inspection. Or a man may ask, "Where did you obtain that weapon of yours?" "Oh, it is a *kaupapa pakuwha* of the daughter of such a person."

The term *whakatakoto pakuwha* seems to apply to any or all of the arrangements for a marriage, from the *taumou* to the marriage feast.

Ope pakuwha always carried their arms with them in former times. It was not well to move abroad without weapons in the old fighting-days, for treachery was a common occurrence, and no man knew when he was safe.

Very often the *pakuwha* party were greeted by a *turanga a tohu*, which is practically a war-dance, all the performers being armed; but it is merely given as an exhibition, and not, as

in time of war, as a species of divination to see what fate has in store for the tribe. The guests were challenged in the orthodox manner as they marched on to the plaza, while the village people would be divided into several columns, all kneeling and waiting for the signal of the fugleman to spring to their feet and, with brandished weapons, to roar out the resounding *ngeri*. In late times a *pakuwha* party is often welcomed with a volley from the guns of their hosts.

Neither the *tumahana*, nor the *pongaihu*, nor yet *whakareka* pertained to the *ope pakuwha*, but only to the *kaihaukai*.*

We will here give a few words of explanation in regard to the careful supervision and arrangement of marriages among the natives. To a great extent it was caused by tribal anxiety to avoid a *mésalliance*, to prevent a person of good birth from marrying into a family of *ware*, or low-born people, to keep unmixed the blood of the *rangatira* class, to uphold the rank, fame, and dignity of first-born lines of descent, and hence to prevent all *tipuheke*, or degeneration, of blue-blooded lines.

For the Maori were ever true aristocrats, ever looked down upon the low-born, and exalted rank and birth. They treated with respect and deference even those members of the aristocratic class who were not endowed with the qualities necessary for the leading of men and the supervision of tribal affairs. And their method of preserving such rank and prestige was by a strict observance and retention of the *aho matamua—i.e.*, of primogeniture. For the *rangatira* or high-born class were descendants of some noted, and probably remote, ancestor through the eldest-born of each succeeding generation, while the lower classes were the descendants of younger sons of by-gone centuries. The first-born lines retained the *mana* (power, prestige) of the tribe, hence they were careful not to allow any of their members to marry into the *ware*, or lower classes—*i.e*, into younger branches—but always within their own class. Formerly, as we have seen, marriages of the "upper class" were arranged by the elders of the young people and by the tribe, in order to avoid such *mésalliances*. But most of these old customs have been deserted by Tuhoe since the advent of Europeans. Young people now please themselves as to whom they marry, hence *tipuheke* abound (*i.e.*, degeneration).

The Maori custom of building a special house in order to signalise, as it were, any important event was a very peculiar one. We have seen that such a house was built in order to emphasize a marriage. A similar custom obtained when

* For an explanation of these terms see article on "Food-supplies of Tuhoeland," Volume xxxv. of the Transactions.

organizing a war expedition, as also to avenge a defeat. The latter was a most peculiar thing. If a people did not consider themselves strong enough to avenge a defeat they often built a special house, after which they invited the people who had defeated them to visit them, upon which they entertained them in the new house during their stay—and that was their revenge.

Another purpose for which a special house was built we will explain by means of a true illustration: When Warahoe were defeated at Taupo, in the fight known as Kohikete, one of their women who was taken prisoner was taken as a wife by Te Rau-paraha. She never returned to her people, who, after passing through many troubles, took refuge at Ruatahuna with the Tuhoe Tribe. But a few years ago her grand-daughter visited the Warahoe people, now living at Te Whaiti, in order to show herself to her grandmother's people. After a time she returned to her home at Poroutawhao, near Levin. Then Warahoe decided to invite her to pay them another visit. So they fell to and built a house at Te Whaiti to mark the event, and prepared food and also gifts for their guest, who duly arrived. She was entertained in the new house for some time, numerous presents were given to her, and she was escorted back to her house by a party of Te Whaiti people. Hapurona said, "*Ko taku kahui tara hai whakahoki i a koe*" ("My flock of *tara* (a sea-bird) shall escort you home"). The term *kahui tara* implied a band of well-born persons. So that house was named Te Kahui Tara.

Nowadays there is none of the *umu kotore* ritual carried out, and but little of the formal arrangements as of old, though a modified form of *pukuwha* entertainments still obtains.

ADULTERY (*Puremu, toukohi*).

Among the Tuhoe Tribe the wife seems to be more frequently guilty of adultery than the husband. An old warrior of my acquaintance informed me that "if a married woman was interfered with in former times it was the cause of serious quarrels and fighting. Men lost their lives thus over women. This fighting over women was not known in ancient times. It began with Maui-tikitiki (thirty-five generations ago), whose wife, Whatu-nui, was interfered with by Maui-mua. That was the cause of Maui turning on Irawaru."

Incontinence, if treated lightly in the matter of young girls, was a serious offence in a married woman, and sometimes severe punishment, even death, was inflicted upon the erring one. If a married man commits adultery both he and his paramour are punished by his wife's relatives by means of a *taua*. The *taua* (hostile party) would be composed of

the wife's relatives. They march to the erring husband's abode and demand satisfaction for the injury done to them and to his wife. Such satisfaction is often in the form of greenstone ornaments, the jewels of Maoridom; also other kinds of portable property, and latterly horses. The wife's relatives would receive such goods, not herself. Such payment in goods is never returned.

If a low-born person or a slave committed adultery with a woman of rank in former days he would probably be slain and, if a slave, certainly eaten.* If a man of rank committed adultery with a slave woman that was thought nothing of.

Both adultery and the abduction of another man's wife were punished by a *taua*, as above described.

In some cases a piece of land is given in payment for adultery, as satisfaction for the injured party. But in after-years such land might be redeemed by the adulterer and his friends handing over an amount of goods (*me unu ki te taonga*) for the same. When Pihi, of Ngai-Te-Au, committed adultery here her people made over to Ngati-Rongo, her husband's *hapu*, a piece of land at Okerekere.

It sometimes happened that a man, for committing adultery with a married woman of rank, had to migrate and live elsewhere. This would depend a good deal upon his own standing in the tribe.

The *taua* which is organized in order to obtain satisfaction for adultery would often, in former times, proceed to *muru*, or plunder, the adulterer's home. In this case a mob of excited natives would rush the place and seize all portable property and carry it off, and would often burn the house down as well. An old saying in connection with adultery is, "*Ko te wahine ma tetehi, ko te whare ma tetehi*" ("The woman for one, the house for the other"). It was bad policy to get in the way of such a party. A rough-and-tumble scrimmage often occurred, in which blood would flow, and sometimes, but perhaps not often, fatal wounds would be inflicted. An aggrieved husband would sometimes fight a duel with the man who interfered with his wife, but it was not a duel to the death. He would be satisfied usually if he inflicted a wound upon his adversary.

The term *kai taonga* is applied to the action taken by parties who ask payment for an injury and such is given without any fuss or violence. It is not applied to *muru*, or violent plundering, as described above.

When a party went to the adulterer's home to demand *utu* (payment, &c.) for his act many speeches would be made,

* As my informant put it, "*Kaore i moua to mua tangata*" ("Men (slain) were not wasted in former times"). He was killed for committing a crime, then, of course, he would be eaten. Why waste him?

and eloquent accounts of the injury received were accompanied by much fierce gesticulation. Such old-time songs as the following were often sung by the first speaker of the party as disclosing the purport of their visit :—

Taku wahine ra
Ka riro koe i Te Tini o Te Manahua
Homai he turuturu, homai he taketake
Hei whakautu mo te manu nunui a Tane
Ka whiwhi au ki te tika—i.

Some time before the fight at Māna-teepa one Te Hau, one of Te Ika-poto's four wives, committed adultery at Te Whaiti. The people of that place knew that trouble would ensue for Te Ika was a person of importance among Tuhoe, so they proceeded to build a fighting *pa* (fort) at Ahi-kereru. Te Ika-poto raised a *taua*, who were armed with guns, and marched on Te Whaiti, where they attacked the *pa*, and after a good deal of firing on both sides the attacking force killed Te Rua-Whakatara of the garrison, after which peace was made.

In a case of adultery which occurred here the wife was the erring party. The goods, greenstone ornaments, &c., handed over by her relatives as satisfaction to her husband were not retained by him, but by an aunt of his. "*Koi nei hai wahine mo te tane, ko aua taonga*" ("The goods were then a wife for the husband").

If a married man committed adultery with a married woman in former times both of them were subjected to a *taua*, and they and their relatives of the family group had to give compensation. Also the husband of the second woman would have the right to *taua* the first man. Or if a married man had connection with a single girl both he and his paramour would be subject to a *taua*, and also if a married woman committed adultery with a single man both suffered. In late times these rules have been somewhat modified. In some cases a man, if of high birth, would repudiate his adulterous wife, very probably at the instance of his friends, who would say, "Discard that woman and marry So-and-so." Adulterous women were sometimes slain by the enraged husband, and would very likely be cooked and eaten, if not closely related, but a member of another clan.

Since the introduction of Christianity another custom has arisen, said to have been obtained from the Scriptures. An adulterous wife is isolated, taken away from the village and camped in a tent or some deserted hut away from any inhabited place. An elderly person accompanies and takes charge of her. After a certain number of days she is allowed to return to the village. Her paramour is sometimes treated in a similar manner. I noted one case here in which a

married man had committed adultery with a single girl, and the man was so isolated, with an old man to take charge of him. In this case the man's wife accompanied him, and acted as cook for the trio.

When Te Iri-o-te-ao, wife of Rongokarae, committed adultery that fine old gentleman set fire to the house in which she and her children were and burned them all to death. When Kai-ahi, of Te Urewera, committed adultery with Ruru's wife Ruru shot and wounded him.

Another custom was for the injured husband to take his adulterous wife to a public trail, where all might see her. He would there lay her down on her back in the track and stretch out her legs and arms and fasten them to pegs. She was left spread-eagled in that manner that all might see her who passed by. Such an act was termed a *whakaineine*.

The form of *taua* known as *taua-a-poke* was a party which demanded payment, and performed the extraordinary actions of defiance known as *pikari*, and sung derisive songs. It was also said to have exalted the wronged wife of the adulterer, presumably by it showing that she must be a person of consequence for her friends to take so much trouble for her.

I knew one case in which a white man married to a native woman was subjected to a *taua* for adultery, and lost some of his horses and also goods out of his store, which were handed over to or taken by his wife's relatives.

The *taua-a-poke** would be directed against a woman who had busied herself in gaining the affections of a married man and induced him to leave his wife for her. The *taua-a-poke* is against women only.

If a wife ran away from her husband he might follow her and try to induce her to return, or he might attack the man whom she fled with, or he might, like unto Rangi-monoa of old, take no steps whatever. Some one said to him, "O Rangi! your wife has fled from you." "Let her go as she goes," replied Rangi, "the Hau o Puanui will bring her back." This was the name of Rangi's food-store, and he meant that she would return when pinched by hunger.

"A woman taken from the shoulder of her husband by another man. The husband girds himself for the fray and seizes his spear. His song is:—

"Kaore hoki taku mate whakaririi—e
Ki te ai puremu—e. Ki te ai maro-nui
Ki te ai whakatutu
Whakatutuki te hihi o te mamaru
Ki roto ki te waha o to puta—e
Ka pati te paraheka tungou tou mea—i."

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* A *taua* sent against a man is termed *taua* only. A *taua-a-poke* is sent against women only.

The shoulder of the husband is looked upon as the pillow of the wife, and is so termed. This form of song is a *tutara*, and is composed and sung by a husband to show his contempt for his adulterous wife, whom it is also meant to degrade.

The following is a *tutara* composed by one Oneone as against his wife Whare-hau, who had committed adultery:—

E paki Whare-hau, ko koe ko te tane
Ka kite iho na koe i te kiriruatanga
I te marotanga o toku nei ure
Taia ki to tara, he karinga na te tonga
He karinga na te kape
Poharu ra i te moana.

In this case, however, the lady replied by composing the following:—

Noho noa taku tara
Ohia noa kia kaupapatia
Nohea e anga iho i te tirohanga kino
Ki te tumatakuru
Te pari ki te mata
Kauaka hoki ra e whakawheoitia
Kai rere au i te pari, tau rawa ko tawhiti
Te motu ra i Pongaponga, e whakakau mai ra
Ko au nei te whanau hai te taingariu
Hai maka i te puna,* hai timo i te punake
Te rongo te taringa i o riri nui ra
Whakarae tonu au ko Hine-hore
Ko au i te motu raia
He whakairinga patu ka mokeke ana
Te tipua tara i riro nei
Mou te turituri, moku te pawera
Hapainga taku tara, rite rawa Hauraki
Te whanake o te hau nui e hori noa mai
Na wai te kai ka whiu, ka maka kai te tahua
Hoki mai whakamuri te kiwi ki Orete
Kai roto mai a Ngaweke
He whakautanga mo Hine-matukutuku
To peru whakanuku ahiahi—e.

Not to be outdone by a woman, the hapless Oneone replied with:—

A TUTARA.

Ehara i toku nui naku anake ia
Naku ra i tohe atu, kia kite hoki au
I mau mai ai ra te tawara ki au
E ware ana au nga matu a Whakaari†
Nga mahi a Kokiri† i waiho ki tana hua
Nga mahi a Rewharewha† i waiho nei ki au.

The expression *tango tu* means to take a wife away from her husband. It is usually caused by *huneinei* (anger, vexa-

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* Puna = punga.
† The co-respondents.

tion). It does not apply to the abduction of a single girl. If a woman marries, say, into another clan or tribe, and in after-time her people are vexed with her husband on account, perhaps, of some slighting remark he has passed about them or about his wife, they will go and take her away from him and conduct her back to their home. That is a *tango tu*. Sometimes the husband's people would show fight and a scrimmage would ensue, or perhaps the former might not consider it advisable to use force. A company of people bent on a *tango tu* would not be termed a *taua*. In a case that came under my notice a girl eloped with a man of Ngati-Whare. They were pursued by the girl's elders and brought back, and the girl was taken from him, as her people would not let her marry him. That was termed a *tango tu*.

I will now tell of the Rua-a-Peka. This is the name of a bathing-pool of warm water at O-hine-mutu, in the Arawa country. A singular old custom pertaineth to this pool. In former times any married woman or man who bathed in this pool was free to have sexual connection with any person she or he might fancy. No objection was made, no *taua* went forth to punish or plunder, for it was an old-time custom, a privilege inherited from other generations. The origin of this singular license is unknown to me, but it is interesting as an illustration of Maori ethics. It is said that the old-time saying, "*Ko Turanga makau rau* ("Turanga of the numberless husbands"), applied to the Poverty Bay district, implied that the married women of that district were somewhat loose in their morals; also that but little notice was taken of such incontinence, an unusual thing in Maoriland.

In olden times, when a man was leaving home on a journey, he would repeat a charm or incantation (*karakia*) known as *taupa* over his wife ere he left, the effect of which was that any man who had connection with her during her husband's absence would perish through the power of the spell.

The Tuhoe saying, "*Toenga mahara nui a Te Wai-haroto*" ("The prized leavings of Te Wai-haroto"), implies that a man when away from his wife did not like to have her interfered with by any one. "*Ngai-Te-Au tara makuku*" is a saying applied to the clan of Tuhoe of that name, a clan famous for the number of adulterous women it contained. A more widely known proverb is, "*Te puapua ka taka i Aromea, he kai na te ure tangata ke.*" This implies that any woman left by her husband for a long time is justified in taking another man as husband, and that the wanderer would have no right to complain when he returned.

An adulterous parent is not allowed to retain any *mana* (power, authority) over her or his children; the other parent

will have control of them. When a couple separate through the adultery of one of them the children are retained by the non-adulterous parent. Still, in after-years the children will probably be quite friendly with their erring parent.

The expression *to paepae* is applied to a woman discarded, repudiated, by her husband (and *vice versâ*) on account of infidelity. It is a belittling expression: she is only fit to drag the beam of a latrine. The term *karawhaea* (scarifier) is a modern word for the same thing, the natives having seen the scarifier cultivator at work on the coastal farms. The discarded adulterer is only fit to do menial work, to weed cultivation-grounds, &c.—said to be dragging the scarifier.

The term *tiko hika* is applied to a woman who has many lovers, as also is the expression *kaikai-rau*. Adultery is termed *puremu*, and also *toukŏhĭ*. *He wahine toukohi* = an adulterous woman.

E whae E! He wahine toukohi koe.—Old Song.

Williams's Dictionary gives this as *tokohi*.

The word *whaiaipo* means a lover, sweetheart, and is here applied to male and female lovers, whether single or married. It is not applied by a wife to her husband, nor by the latter to his wife. The term *kari hika* implies frequent sexual intercourse. The star Părĕārau is spoken of as a *wahine kari hika*, or *wahine tiweka—i.e.*, a lady of indifferent character.

We give a few specimens of such songs as were composed by natives in connection with adulterous women:—

A Song, composed by Kahua, whose Wife had been tampered with.

Kaore taku raru
He rau tahuritanga ki te whare ra
I whakawarea au e koe ki te tama iara
Na Te Pu-Whakahara ou ngutu
Te hohoro ki nga kokinga rau
Tenei te kurehu nei, he moe po pea i au ra
Ko te moe he mea tenei au kai runga
Te torohanga tini whetu ki runga i te rangi
He whakahinga noa koe i a Tane-mahuta
Ki nga uru kiokio
Ki nga paruparu ki O-Tu-whai-ao
Rere pu o korua mauri tee tika i te ara
Tapahi noa i te whenua
Apiti rawa atu ki te takotoranga o Haumia
Ki te aka o te whenua
Totoro to waewae hai ringaringa
Totoro to ringaringa hai waewae
Ka takoto te ika whenua o te rangi
Katahi ka auraki mai
Ki te whanau a te mangumangu kikino
Ki te aitanga a Punga i au—e.

A Song by Te Rere-ure concerning his Adulterous Wife.

Tenei au te ware nei
Tera koe te tu noa ra
Te ako noa ra i te rakau a Tu-tawake
I te hani kura, i te kawau ruku roa
I te kawau māro
He kura takahi puni tenei.

A Song by Te Ahoaho for his Wife, who was an Adulteress.

E muri koe awatea nei
He whakaputanga no te wairua
I rongo pea koe i te ki
Whakarerea te waka to kau
Ka pa hoki ra hai te waka whakairo
Kia mau ai, E hine!
Whai atu koe ki a Tama-houtake—e
Ki te ure i puhia ki te kura, ki te awe
Ki te raukawa—e,
Ki te kanohi pokaia ki te whao
Ki te uhi maitai
Na te tipua ako noa ake nei ki te mahi
Koua kitea te kinonga
I te po tata o te raumati
Kai tawhiti ra a Te Ahoaho
Hai hi mai i te ika nei
I te tuatini, i te nanua pounamu
Hai kai ma te wahine
Ki mai ki ahau—e
He aha ahau te tito ai ki to tara
Ko ana mokopuna naku ra
Kai pakupaku tete noa i waenga o te tara
Miminga a ringa mai na tohou ure
He ure i puhia ki te kura
I whakataua ki te tama
Na Ruru-tangi-akau-roa e tete noa mai ra
E whākapi mai ra i te one o Tatai-arorangi
Tenei ka haramai
Ka tipi rawa i te momo o te tangata
I hikaia to tara ki te ahi koe
Nau, E Tapeka! I tora i te whenua
Ka rere te kora ki te rakau
E tuhi ana, e rapa ana
Kai te uiratanga mai, kai te koha
Kai te pou taka mai i runga i te rangi
I kai whiri ai koe ki te ure wai kore
Ki te ure tipua, ki te ure i a Tahurangi
Ka mau te hu ki to hengahenga
Ka taka i te mutunga.

It sometimes happened that a man would be so vexed by the infidelity of his wife that he would not only forsake her, but also leave the district for ever and live with some other tribe. When Kopura, wife of Tihori, a famous ancestor of Ngati-Awa, went wrong with Whare-pukaea, her husband's younger brother, Tihori left the district and migrated with some of his people to the north, where they settled among the Ngapuhi Tribe. Hongi Hika was a descendant of Tihori. As Tihori was leaving in his canoe his wife came down to the

beach and called out, "Return to me and to our children." Tihori replied, "Farewell! *He tamariki tonu kei te mata-mata o taku ure*"—a similar reply to that made by the revolting Egyptian troops when asked to return during their march south, as described by Herodotus.

When a married couple among the natives quarrel they do so in a remarkably noisy manner, as is usual in all Maori squabbles and quarrellings. They shout at each other and gesticulate, and indulge in all kinds of defiant language and gestures. They have no compunction whatever as to washing their soiled linen in public. Also *whakamomori*, or acts of desperation, are sometimes committed. An Arawa woman whose husband had been unfaithful to her threw herself into a boiling spring—a fearful death. In another case in this district a woman left her husband on account of a quarrel, and, on his pursuing her in order to bring her back, she jumped over a high cliff. Wives often leave their husbands in this manner in this district, but they usually come together again ere long.

Polygamous wives sometimes quarrelled among themselves, as when Uenuku-koihu's two wives, Maru-hangaroa and Kahu-kura-kotare, fell out, and the former made away with the latter by means of the magic rite known as *umu pururangi*.

In the days of yore native children were usually naked, though girls often wore a rude *maro*, such as a bunch of tow fastened on with a string—*hai huna i te aroaro*. That was in childhood; but women never went naked, although men sometimes did. A woman would not be seen without her *maro*, a kind of apron or kilt. Note the term *maro-nui*, used to denote a married woman, and which signifies "big apron." This is significant of a change in their clothing made at marriage or at puberty.

There dwelt in former times at O-potiki a married woman named Mahuru, who for some reason left her husband and came to Rua-toki, where she married one Takarehe. And it fell upon a certain fine day that the fair one prepared some fern-root for her better-half's dinner. However, she neglected to remove the fibres from the meal, whereupon Taka arose in his wrath and struck the erring one upon the head with his weapon as a token of his disapproval of her indolence. Mahuru said, "You may now marry your weapon as a wife for you," and fled to her father, Tamahape, who was peacefully weeding his *kumara*-garden. As she came to him Tama saw the blood flowing from her wound, and said, "You are a survivor." Mahuru said, "It was my husband; he is following me." "Remain here by my side," replied Tama. When Taka arrived he attacked Tama, who parried his blow and slew Taka, whom he and his daughter cooked and ate. Thus

Taka was useful even in death. He filled a long-felt want, doubtless. This anecdote is inserted not only as an item of ethnography, but also as a hint to any ill-used wives, and as a warning to those who assault their devoted wives.

Divorce.

That there was a ritual of divorce which obtained among the old-time Maori is certain, but it is not clear that when a couple wished to separate they had recourse to the same. Some natives state that it was so used, but there is evidence in favour of the statement that it was more often utilised as a means of separating husband and wife by one who wished to marry the husband or wife, as the case might be.

Tikitu, of Ngati-Awa, states, "Suppose that you have two wives, and that one becomes jealous of the other. She comes to me, the *tohunga* (wise man, priest, shaman), and asks me to separate her rival and their husband, to cause her to leave him, that she, the applicant, may then be the only wife. To effect this separation I have recourse to the *toko* rite. The *karakia toko* (divorce invocation) separates a couple by causing their love for each other to cease. The same invocation is used in all cases, whether the parties to be separated are willing or not. Suppose that my daughter marries you; although you love each other, yet if I take my daughter to the priest and he recites the *toko* invocation over her then she will no longer feel any affection for you. And should a man wish to be rid of his wife and to marry some other woman, if his wife is willing then he goes himself to the priest."

Another authority, and a more learned man than Tikitu, says, "The *toko* is a *karakia* (invocation, charm, incantation, ritual) to divorce a married couple who have no desire to separate, but whose elders wish to part them. The priest takes the couple to the water (where rites are performed) and sprinkles them with water, then repeating over them the *karakia toko*:—

> "Ka tokona atu nei korua
> Tu ke Rangi, tau ke Papa, &c.

The couple are thus divorced."

My own particular sage, he who has long endeavoured to guide me through the mystic gloom of the *whare takiura*, explains thusly: "A married woman comes to the priest in order that he may cause her love for her husband to cease (*kia miria tona aroha*). The priest takes the *ahua* (semblance or personality) of her affection at the sacred waters, whither he conducts her, and there he 'separates' her affection from her and abolishes (destroys) it—that is to say, he washes the *aria*, or *ahua*, of her love away. Then the priest recites the *toko* invocation:—

"Toko te rangi
Tu ke Rangi
Tau ke Papa-tuanuku.
Nga rakau i te ngahere
Te homai mo to kiri
Kia tūtū, kia wewehi mokinokino
Nga otaota i te ngahere
Te homai mo to kiri
Kia tūtū, kia wewehi mokinokino
Nga ongaonga i te ngahere
Te homai mo to kiri
Kia tutu, kia wewehi mokinokino.

This has the effect of destroying her affection, and of causing her to fear her husband. She will not approach him again."

In this account of a singular ceremony the priest takes the applicant for divorce to the stream, pool, or spring set aside for the performance of sacred rites thereat, and there he sprinkles her with water, and takes from her the formless, immaterial personality of her affection for her husband. This he does by just touching her body with his fingers, as if picking or plucking something from her. This semblance or likeness of her love he washes off or away, as it were, and so it is *miria*, or separated from her. In his invocation he calls upon the sky to stand apart, on high, and be separated from earth; and also upon earth to lay separate from the sky; and upon the nettles, and plants, and shrubs, &c., of the forest to cause the skin (metaphorical) of the applicant for divorce to rise, "like quills upon the fretful porcupine," in dislike of her husband.

The term for divorce (*toko*) is taken from the act of Tane of old, he who performed the first divorce on record when he separated earth and sky—for this is an animistic myth, old as man himself. Rangi is the Sky Parent, the personification of the heavens, whose wife was Papa-tuanuku, the Earth Mother (the Ouranos of Grecian mythology). This primal pair originally embraced each other, hence the world was in darkness until Tane separated the parents of gods and men by thrusting up the heavens, an action described by the word *toko*. Observe the allusion to this in the first three lines of the divorce invocation.

The term *toko* is also used to imply the abolishing and driving-away of a high wind by the repeating of a charm known as *tokotoko*, commencing—

Tokona nga hau
Tokona ki waho, &c.

A *toko*, or divorce invocation, is given at page 296 of "Nga Moteatea."

The following is a portion only of another *toko* :—

Kia ongaonga to kiri
Kia rere pari
Kia wehea i runga
I a Papa-tuanuku raua ko Rangi
I tokona nei e Paia, &c.

Paia is another name for Tane.

In the above crude ritual we observe how our own sacred rites have originated. The primitive divorce rite here given was a religious ceremony of the Maori, though we prefer to term such items superstitions, or necromancy, or magic, or some such title. The invocations of the *umu kotore* were the beginning of a marriage rite from the like of which our own ceremonial system has sprung. Far back in the remote past the men of old strove to build up social systems, to evolve social laws, that would benefit class or nation. Ancient Egypt and ancient Chaldæa broke out the trail by which the Maori travelled in the years that came after. Ever striving, ever seeking, making for self-advancement, for national advancement, led on by fanaticism or love of study, and of knowledge, and of power, the men of yore groped their way through the gloom and evolved rites and laws, selfish, superstitious, brutal, or unjust at times, but the prototype of our own.

It does not appear that a woman could repudiate her husband without just cause. If she disliked him much and persisted in her design to leave him it would probably be agreed to.

Separations are rather common among the Tuhoe Tribe nowadays, sometimes after children have been born.

Widows and the Levirate.

At the death of her husband a woman would make it her business and pleasure to join in the extravagant mourning of the Maori, marked by laceration of the body and doleful wailings. Not infrequently widows committed suicide by strangulation or starvation on the death of the husband out of grief and affection (*ka whakangakau ki ta ratau tane*). Moerenhaut seems to imply that they were strangled on the tomb of the husband, but my authorities make it self-destruction, not at the hands of another person.

The term *maro purua* is applied to a woman who marries again after the death of her husband, in which case she might retain her children by the first husband, or her relatives might adopt and rear them.

The levirate was essentially a Maori custom—that is to say, the custom of a widow marrying the brother of her deceased husband. It was evidently an ancient law, and appears to have been generally followed. The widow was

expected to so marry whether the brother were older or younger than her deceased husband. This new husband often assumed the name of his dead brother, discarding his former one. He would *whakanoa* (make common, free from *tapu*) the bed of his departed brother, for both bed and widow would be *tapu*. Should the widow refuse the brother and marry some other man, such action was considered wrong, and an offence. Hence the relatives of her former husband would probably attack the new one, burn his house, and possibly slay him. Wars have sprung from such occurrences. After the widow had married the brother, should she take a dislike to him she might he divorced from him by the priest, and could then marry any one she liked, because she had become *noa*, or free from *tapu*, by first marrying the brother of her former husband.

A widow would not marry again soon after her husband's death. Were he a person of importance she would probably remain a year in the *whare potae* (or *whare tauā*—house of mourning—a figurative expression). A widow would not refuse to marry again. It was also a common thing for a man to marry the sister of his wife, sometimes during the life of the latter, at others after her death.

The levirate was in force among the Hebrews of old and many other peoples. Letourneau appears to think that it became law among barbarous peoples in order to provide the widow with a protector and a living withal, but this scarcely seems to apply to a communistic people.

Widows of men slain in fighting often married those who avenged their husband's death. If taken prisoners in battle, women were generally appropriated by members of the victorious party.

Notes concerning various Customs connected with Marriage.

It was sometimes the case that a single woman would be given as a temporary wife to a visitor of distinction, but a married woman would never be so offered. A case of this kind came under my notice in this district not long ago, the recipient being a white man not particularly distinguished.* An amusing story is told of one of the bishops of the English Church receiving such an offer in the early days. I am not aware as to whether it was accepted or not. Even of late years we have heard of wives being sold in England, and in an issue of the London *Times* of 1801 appeared an account of how a man put a halter round his wife's neck, led her into a public place of the city, and sold her.

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* Unless joining in French's ride to Kimberley made him so.

The reason why girls were usually tattooed before marriage was that red lips were not considered sightly, but were disliked. Women are still most conservative in having their lips and chin tattooed.

There is no evidence to show that the *jus primæ noctis* ever obtained among the Maori, but a man who held the power that a priest did might claim almost any girl he desired, with a very good chance of getting her. I have seen that sort of thing in Mexico, where the peasant class are not a bit more advanced in regard to religion than are the Maori.

When a man had been befriended or assisted in some way by another, and he felt that he would like to make some return, he would perhaps give his benefactor a piece of land. Or on his death-bed he might say to his daughter, "When you are grown up marry our benefactor; do not heed the fact that he is much older than you" (*Ka whakatutu ki tana tamahine, "Ki te ngaro taku kanohi, ki te puta to ihu, me moe i a mea, ahakoa he kaumatua ia"*).

Natives say that it is the correct thing for a wife to leave her home and live with her husband among his people. This was not always the case among the Tuhoe Tribe; the husband sometimes settled down with his wife's people. Hence it will be seen that no hard-and-fast rule obtained in regard to this matter. I have noted that several women of distant places who married men of this district, and whose husbands died before them, returned to their parents' home after the mourning ceremonies, &c., were over.

A man who lives with his wife's people might perhaps be given a piece of land by them, and his children by her would inherit such land. If, however, the couple have no issue, the husband would not retain the land after the death of his wife, and he would then probably return to his own people, the land returning to the original owners. This simply amounts to his cultivating, &c., on his wife's right to such lands.

When a man of rank married a low-born or a slave woman she would have no *mana* (power, influence) or standing in the tribe, but their children would not only be free, but would inherit the rank, &c., of their father. No one would call them slaves or low-born, except that in quarrelling a person might say, "Your mother was a slave, or a low-born person." The same result would follow should a low-born or slave man marry a woman of rank. Tareha, a chief of great *mana*, of Heretaunga, was the son of a slave woman captured at Kohi-kete.

I have noted that after a man marries he will, when he obtains something suitable, make a present to his parents-in-law. Also that if a wife's parents see that she is badly off they often try to help her by giving her things; or if the latter

be well off she may assist her parents. No special clothing or furnishing is prepared or made by a woman when she marries. When married those of the highest rank receive the most presents, useful and ornamental, although there is no recognised system of making wedding-presents, as with us.

A man shows no avoidance of his parents-in-law, as among some races; he is, on the contrary, often more friendly with them than with his own people.

In a marriage between persons of equal rank the husband has the greatest *mana* (authority, prestige), both in regard to property and also in respect to the conducting of tribal affairs. Taking the family of such persons, the wife would be the next in authority; and of the children the eldest son takes first rank, then the eldest daughter, then come the younger children, male and female. The youngest child would possess the least authority of all the children.

If a woman of rank marries beneath her she will always retain her superior *mănă* and rank above her husband. Still, this woman loses caste to a certain extent by such a marriage, and the tribe will say that she has lowered herself by marrying such a man (*ka karanga te iwi, na te moenga i te tane hehe i tipuheke ai taua wahine*).

"When Kareko married Timoti she committed an offence, for she was of high birth while he was a *ware* (person of low birth). Hence Ngati-Tawhaki sent a *taua* (see *ante*) to demand satisfaction, and I handed over to them a piece of land known as Matawera as *utu* (compensation)."*

We will now give a few proverbial sayings of the Maori, and a short list of terms and expressions which may be of some interest in connection with our subject:—

"*Te inati o Mawakeroa.*"—This saying is applied to the passing-away of a woman and her *mănă* (power, prestige, authority) from her own people or clan when she marries. A son marries and abides with his people, but a daughter marries and goes to live with her husband's people, taking her *mana* with her; she deserts her kin for a husband.

"*Mau te wahine, maku te whenua, kia ai koe i te tore tangata, kia ai hoki au i te tore whenua.*"—To you the woman, to me the land, that you may breed men while I breed food.

Tane moe whare—E, kurua te takataka!
Tane rou kakahi—E, aitia te ure!
(An indolent husband—thwack him on the noddle. An industrious husband—be kind to him.)

Tane = man (*vir*), male, husband.
Wahine = woman, female, wife.

* From Wi Patene's evidence in Hikurangi Block hearing.

Hoa = friend, mate, companion, also spouse. *Taku hoa wahine* = my wife; literally, "my female companion."

Takakau = single person of either sex.

Maro-nui—He wahine maro-nui = a married woman — a woman with a large apron, literally. But only applied to women who have been married according to tribal customs, everything duly arranged, not to adulterous unions or mere cohabiting.

Makau = lover (male). Among some tribes it means "spouse."

Pouaru = widow, widower.

Pani = orphan, widow.

Moe = to sleep, also "marry." The term *noho* is also used to denote marrying—*Ka noho a Toi, ka noho i a te Kura.*

Ringa hoea = rejected hand. Applied sometimes to a rejected suitor, but not used in that sense alone.

Reperepe = the buttocks (also *tareperepe*). *Kai reperepe* = *kai kotore* (see *ante*).

Eweewe = blood relation.

Moe tahakura = to dream that one is in the company of a person who is really dead, as one's late wife.

Moe tahurangi = to dream that one is with an absent, but living, woman, as one's sweetheart.

Titoi = masturbation.

Regarding repudiation: At the present time when a man wishes to repudiate his wife—and in most cases of separation nowadays the cause is the husband's desire for another woman — his elders try to patch the matter up and to persuade him not to repudiate her. The blame in these cases of separation is laid upon the one whose fault it was. If the woman was in fault it will be said of her, "*Ou mahi a te wahine tutua*" ("Just like a low-born woman").

We have now come to the end of this paper, for the above notes are all that I have collected on the subject of marriage among the Tuhoe Tribe. There is much left unrelated, but many most interesting facts in connection with Maori rites and customs will never see the light, for the men of old took the knowledge thereof with them when they lifted the old-time trail to the setting sun in search of the Children of Pani.

For a barbarous people, the Maori treated their women well, and gave them considerable freedom and authority. Of course, neither sex were overburdened with modesty: they spoke openly of things which we only speak of in private or not at all. It is difficult for us to examine these customs, rites, superstitions, and ideas of a primitive people with an unprejudiced mind (if not quite impossible), but, could we do so, the Maori system of arrangement of marriages would be seen to be a very good one for a primitive and communistic

people, inasmuch as it was a useful stage in the evolution of that moral discipline which is necessary to the advancement of a people. Their passions were not, and are not, disciplined by long centuries of self-control and repression; they are nearer to nature, and not so imbued with artificial ideas, such as modesty, as is civilised man. Perhaps this lack of long training is why the morality of primitive peoples appears to degenerate when they are brought into contact with the intrusive white man. When I was living in Nevada I often saw Indian men offering their wives to workmen in the rail-road camps; yet old pioneer settlers informed me that when they first knew the natives such a shameless custom was unknown. Indeed, any of the native women who accepted the advances of a man other than her husband in those days was simply burned to death.

The evolution of morality among the Maori has been rudely broken by the great changes that have overtaken them. We shall see in the years that lie before if the chain can be mended.

But do not try to drop too many links.

Art. V.—*The Sparrow Plague and its Remedy.*

By A. Bathgate.

[*Read before the Otago Institute, 8th September, 1903.*]

Sir Walter Buller, in the introduction to "The Birds of New Zealand," writes, "To my mind the popular outcry against the sparrow is scarcely warranted by the actual state of the case. It is only at one particular period of the year, when the farmers' grain is 'dead ripe,' that the bird makes any inroad upon it. In large fields the loss is barely noticeable; but in the case of a small patch of grain—say, an acre or two—at the edge of the forest or in a bush clearing it naturally becomes a serious matter, because the sparrows appear to concentrate their forces on such inviting spots, and leave practically nothing but straw for the reaper. Hence, of course, the outcry and clamour on the part of the small farmer. But if people really knew how much the country is indebted to this much-abused bird I venture to think that there would be a still louder outcry against the sinful practice, now so general, of poisoning sparrows." He then goes on to assert that the "young birds are fed entirely and exclusively on animal food. Every five minutes or so during the long summer day one or other of the parent birds visits the nest, carrying in its bill a

caterpillar or a grub, a beetle, fly, or worm, but never a grain of corn or fruit of any kind." In support of his assertions he quotes in a note an anonymous "newspaper record" telling of the examination of the contents of the stomachs of 118 sparrows by an unnamed investigator, which showed that three of the birds had eaten nothing but grain for the preceding twenty-four hours, seventy-five had partaken of little besides insect food, while insects had formed a large part of the diet of the remainder. The value of this quotation would have been enhanced had some clue been given to the identity of the investigator or the locality where the investigation was conducted.

As Sir Walter Buller pleads guilty to being accessory to the importation of the sparrow into the colony, it is possible he may be somewhat prejudiced in its favour. One small inaccuracy may be noted. Sir Walter asserts that it is only when the farmers' grain is "dead ripe" that the mischief is done, but I think most farmers will tell you that the birds begin their depredations when the grain is in the milky stage, and do not desist so long as the grain is accessible.

I dare say there are still a few people who are of the same opinion as Sir Walter Buller, and who will contend that the house-sparrow repays in some measure the injuries it undeniably inflicts by the benefits it confers by destroying injurious insects. Such persons say that, while the evil wrought is manifest to the most superficial observer, the good they do is hidden from most eyes. This latter statement, while true regarding many birds, whose good deeds far outweigh their trifling misdemeanours, is, I fear, a fallacy as regards the sparrow. The assertion made by Sir Walter Buller that the sparrows feed their young entirely upon insects is one which requires confirmation. The idea that because the bills of the young birds are soft they must of necessity be fed on soft food, which I have heard urged as a proof of the statement regarding the food of the young, seems to me most fallacious. As the food is dropped by the parent into the gaping mouth of the nestling, and is gulped down at once, the texture of the nestling's bill can hardly be a factor in determining the nature of its food. That sparrows do destroy a good many insects I readily admit, but I feel assured that any services they thus render are comparatively trifling and would be better performed by other birds, and are unworthy of consideration.

Some few months ago there came into my possession a book published by the United States Department of Agriculture (Division of Ornithology and Mammology, Bulletin 1), entitled "The English Sparrow (*Passer domesticus*) in North America." It is a thick pamphlet of about four hundred pages, and bears abundant evidence of the thorough manner

in which the Department referred to performs its work. In reading it I was struck by the judicial manner in which the compilers have marshalled the facts collected, and I think that no unprejudiced person would fail to concur in the verdict, which is a complete condemnation of the sparrow. I do not purpose following in any detail the various ramifications of the inquiry, but I shall refer to some of the evidence adduced.

The Department dissected at Washington 522 sparrows, of which 338 were obtained in that neighbourhood and 184 were sent thither in alcohol from other places, whilst another lot of 114 were dissected at Westchester by competent men. The birds were obtained from time to time throughout an entire year; the contents of the stomach were carefully examined and the results tabulated. Any which contained, or were suspected of containing, insect-remains—102 in all—were sent to Professor C. V. Riley, of the Entomological Department, who further examined the contents and classified the insect-remains, the horny head of a caterpillar or the leg or wing-case of a beetle being sufficient to enable him to determine at least the genus to which the insect belonged. Out of the 102 stomachs examined by Professor Riley 92 were found to contain insect-remains. In 47 of these noxious insects were found, beneficial insects in 50, and insects which were harmless or of no economic importance in 31. So that out of these 522 sparrows only 47, or a trifle over 9 per cent., had conferred the slightest benefit on humanity.

In a pamphlet entitled "The House-sparrow," published by the late Miss Ormerod, the well-known entomologist, and Mr. W. B. Tegetmeier, the authors arrive at the conclusion that the sparrow is an unmitigated pest, and support their view by evidence drawn from various sources. Amongst others quotations are given from a publication by Mr. J. H. Gurney, of Keswick Hall, near Norwich, England, also entitled "The House-sparrow," which contains a table showing the contents of the stomachs of 694 sparrows examined by qualified observers in different places at regular intervals throughout the whole year, and the results are summarised by Mr. Gurney as follows: "It may be said that about 75 per cent. of an adult sparrow's food during its life is corn of some kind. The remaining 25 per cent. may be roughly divided as follows: Seeds of weeds, 10 per cent.; green peas, 4 per cent.; beetles, 3 per cent.; caterpillars, 2 per cent.; insects which fly, 1 per cent.; other things, 5 per cent. In young sparrows not more than 40 per cent. is corn, while about 40 per cent. consists of caterpillars, and 10 per cent. of small beetles."

In Hardwicke's "Science Gossip" for 1883 it is recorded that Mr. A. Willis, of Sandal, examined eighty-seven sparrows' stomachs in 1882, and found insects in eight only.

Dr. Edward Crisp examined 100 stomachs of young sparrows before the British Association at Birmingham in 1865, and not 5 per cent. of them contained insect food.

Mr. John Cordeaux opened the crops of thirty-five young sparrows of various ages, and found on an average two parts of soft grain and one part of insects.

Colonel Champion Russell, of Stubbers, near Romford, Essex, examined the contents of the stomachs of sparrows shot over a wide extent of country for fifteen years, and he gives the result of his observations in the following words: "On the whole, the deduction from the food test during fifteen years seems to be that sparrows are useless, and that the insects which would be given to their young by them if they were allowed to live in numbers about my premises would be so much food taken when they most want it from better birds, which live entirely, or nearly so, on insects."

In an essay entitled "Birds in the Field and Garden," by Champion B. Russell, presumably the same gentleman as the one from whom I have just quoted, there occurs the following passage: "Personally, I consider that only one bird should be shot 'on sight,' and that is the domestic sparrow, whose relations to man are on a par with those of rats, mice, and other human parasites." Now, the essay referred to is the first-prize essay published in February, 1903, by the British Society for the Protection of Birds, and one would expect that coming from such a source the bias, if any, would be in favour of the bird; but the condemnation is unsparing.

Turning again to the American report, I find in the table the birds are, under the heading "Age and Sex," indicated by the abbreviations "ad.," which I assume stands for adult, "juv." for young, and "im." for immature, which I take to be nestlings, and, taking a couple of the latter at random, I find that one contained wheat, oats, and grass-seed, and no insects, and another wheat and the remains of one beneficial insect.

But it is unnecessary to pursue this branch of the subject further, as I think that in the face of such evidence it would be difficult for the friend of the sparrow to maintain his defence, and that Sir Walter Buller's assertion that the young are fed exclusively on animal food is disproved.

I may here call attention to the fact I have already referred to—that the American investigators found that, while injurious insects were found in only forty-seven stomachs, beneficial insects were found in fifty and harmless insects in thirty-one; so that even in the matter of the destruction of insects the sparrow does as much harm as good.

In another publication by the Agricultural Department of the United States, dealing with the native insectivorous cuckoos, it is stated that the food of these birds was found to

consist almost exclusively of injurious insects, with but a small proportion of beneficial or innocuous kinds.

Before closing my indictment of the sparrow I shall refer to one aspect of it which the American observers consider sustained—namely, that it drives away from its neighbourhood the purely insectivorous birds, and thus allows injurious insects to increase in such localities. Professor J. A. Lurtner, State Entomologist of New York, writing of the increase of the caterpillar of the tussock moth, which is very destructive to trees in many parts of the States, says, "The extraordinary increase of the *Orgyia cucostigma* is owing to the introduction and multiplication of the English sparrow. This may seem a strange statement in consideration of the fact that the sparrow was imported from Europe for the express purpose of abating the caterpillar nuisance in New York and some of the New England cities. . . . The increase of the *Orgyia cucostigma* commenced and has continued to progress with that of the sparrow. A remark made to me that the caterpillars had been observed to be very numerous in localities where the sparrows also abounded induced me to undertake to verify or disprove the idea that had suggested itself to me that the sparrow afforded actual protection to the caterpillars and promoted their increase." After giving details of the observations, he goes on to say, "That the sparrows decline to eat the *Orgyia* caterpillar is not a charge against them. They could not eat them with impunity. The diet would doubtless prove fatal to them. The charge to which they are amenable is this: By the force of numbers, united to a notoriously pugnacious disposition, they drive away the few birds that would feed upon them." The authors of the English pamphlet from which I have quoted concur in the view expressed by the American investigators that the sparrows drive away more useful birds, and I am by no means sure that we might not have similar cause for complaint here, as some of our native insectivorous birds, such as the tomtit (*Myiomoira macrocephala*) and the fantail (*Rhipidura flabellifera*), are much less numerous in the neighbourhood of Dunedin than they once were. It is probable, however, that the increase in the number of cats may have been the main cause of the diminution of the number of the former, though the advent and increase of the sparrow, I am inclined to think, has been a considerable factor.

I shall not take up your time by dwelling on the minor counts of the indictment, such as the injuries to fruit and vegetables, and the damage to and disfigurement of buildings by their nests, as I think I have already made out a strong case against the sparrow, and, having done so, I shall now consider the remedy.

In America there are many checks to the increase of the sparrow which are lacking here, such as the severe winter and natural enemies, so that it behoves us to take more strenuous measures than our American cousins to combat the existing great and steadily increasing nuisance. Yet I find the following passage in the American report: "The English sparrow is a curse of such virulence that it ought to be systematically attacked and destroyed before it becomes necessary to deplete the public treasury for the purpose." The pamphlet reviews the various methods of combating the nuisance, such as poisoning, trapping, shooting, paying a bounty for eggs and heads, and even utilising the sparrow as an article of food. Under the latter heading it mentions that the sparrow is excellent eating, equalling the smaller game birds. "In fact," it says, "at restaurants it is commonly sold under the name of 'rice-bird,' even at times of the year when there are no rice-birds in the country." I do not know that we are advanced enough or possess a sufficient number of gourmets to create a market for sparrows for the table, but in Calcutta a species of lark is caught in large numbers and is so utilised, not merely fresh but also preserved in tins, and they are sold under the name of ortolans, so perhaps some day our preserving-works may be employed in canning sparrows to masquerade under the name of New Zealand ortolans.

Poisoning does not appear to have been so successfully carried on in America as here, while trapping appears to have been conducted on a very limited scale, and the method of destruction most favoured seems to be shooting. Speaking of this mode of destruction, the writers say, "The sparrow is a cunning, wary bird, and soon learns to avoid the means devised by man for his destruction, hence much sagacity must be displayed in the warfare against him. In the winter-time, if food is placed in some convenient spot at the same hour each day for a week, the sparrows will gather in dense flocks to feed, and large numbers of them may be killed at one time by firing upon them with small shot. By spreading the food along a narrow strip of ground which can be raked conveniently from some hiding-place the best results can be obtained." This mode may be very suitable in a country where the ground is covered for weeks with snow, but it would not, I fear, prove very efficacious in New Zealand.

The bounty system is considered at some considerable length, and is condemned as being unsatisfactory and expensive, a view in which I concur. Time will not permit my discussing this aspect of the question, but one objection is that the young of beneficial birds, such as the hedge-sparrow (*Accentor modularis*), or of the harmless ones, such as the goldfinch (*Fringilla carduelis*), are to the ordinary individual

indistinguishable from those of the destructive sparrow or equally obnoxious green linnet (*Chlorospiza chloris*), so that the destruction of beneficial and harmless birds is encouraged and rewarded.

Our County Councils have chiefly adopted this method of fighting the pest, and many of them have encouraged in divers ways the killing of sparrows and green linnets by poison, but beyond this and the placing on the statute-book of an Act or two no systematic attempt has been made to combat the evil. I shall therefore proceed to show you what appears to me a more excellent way.

The means the adoption of which I advocate are of two distinct kinds, systematic trapping and the introduction of the natural enemies. It is well known that expert English bird-catchers can capture unlimited quantities of birds of almost any variety. To such an extent has the catching of birds been carried in the Old Country that the Legislature has been compelled to pass a Wild Birds Protection Act. These bird-catchers devote their energies chiefly to the taking of song-birds, and some idea of the extent of the trade may be gathered from the following extract from the *Illustrated London News* of the 10th January last, when it is recorded that "in a recent London County Court case the defendant stated that he generally bought a hundred dozen linnets, skylarks, and other British song-birds a week. For linnets he paid £2 for ten dozen." If there was any market for sparrows I am sure that the price would be very much lower. I therefore suggest that each County Council should be compelled by law to employ at least one expert bird-catcher, who would be instructed to devote his attentions to sparrows and green linnets only, with perhaps an occasional raid on the blackbirds, and that they should have power to levy on all municipalities within or on their borders a proportion of the cost of their operations. This, I am certain, would be cheaper and much more efficacious than the bounty system.

My suggestion that the municipalities should contribute to the cost is because the towns are the nurseries in which the sparrows to a large extent multiply. This fact is noted in the American pamphlet, and not long ago I had local confirmatory evidence on the point. A gentleman residing in a suburb of Dunedin had acquired the habit of every morning throwing some pieces of bread to the sparrows, and deriving amusement from their antics in squabbling over the spoil. He continued the practice for some months, but one fine morning no sparrows came, nor when he returned from business in the evening was the bread gone. For some weeks he observed few, if any, sparrows; but after a time they returned, and he resumed his habit of feeding them, and continued it through-

out the year, until again there were no sparrows. This set him thinking, and he realised that the season was the same, and that it was the time of the ripening of the grain. There was only one inference, which was that the absence of sparrows was due to the fact that the little wretches had all gone harvesting. It is therefore only fair that the towns, which, of course, in any case live on the country, should contribute to the destruction of the sparrow; and no doubt every suburban grower of gooseberries or green peas would gladly contribute his quota towards keeping the pest within bounds. Were such a system adopted, coupled with the introduction of their natural enemies, which to my mind is the surer remedy of the two, the small-bird nuisance would soon be a thing of the past.

At the recent conference of the acclimatisation societies held in Wellington Mr. A. C. Begg brought forward a resolution in favour of the introduction of enemies to the destructive small birds, but with the characteristic fear of such bodies of repeating any of the mistakes of the past the conference would have none of it. Such fears, in my opinion, arise from the same lack of knowledge on the part of many of those controlling our acclimatisation societies which led to the introduction in the first place of the sparrow and green linnet.

It only remains to consider what should be introduced to keep the sparrow within bounds, for extermination is not now to be looked for. Various birds have been suggested, such as jays, magpies, and owls, and our local society have already turned out a few barn-owls (*Strix flammea*), a species I do not consider the best for the purpose, though undoubtedly a useful bird, its favourite food being rats, mice, voles, and such small deer, but it will take small birds also. The long-eared owl (*Strix otus*) or the tawny owl (*Ulula stridula*) prey on small animals also, including rabbits, but are, I believe, more addicted to capturing small birds than their barn relatives.

The jay (*Garrulus glandarius*) apparently renders good service in America, as Dr. S. M. Hamilton, of Monmouth, characterizes it as one of the sparrow's worst enemies. It is, however, a forest-haunting bird, while sparrows avoid woods. Morris, in his "British Birds," gives the following account of its habits and food: "The bird," he writes, "is exclusively addicted to woods and their immediately neighbouring trees for its habitat. . . . The acorn is the most choice 'morceau' of the jay, and for this he even searches under the snow; but he also feeds on more delicate food, such as beans, peas, and cherries, as well as on beech-nuts, grain, garden and wall fruit, berries, corn, worms, snails, cockchafers and other insects, larvæ, frogs and other reptiles, and mice, and is deterred by no scruples or qualms from making away with

young birds, even partridges and eggs." This extensive *menu* is a little jumbled up by our author, but apparently from his putting young birds last he does not deem them the most important item on the bill of fare. Probably in the States during their severe winter the jays may be driven in from their woodland haunts to seek their food amongst men and sparrows. It appears to me that it would not be desirable to bring the jay here, where the conditions are so different.

The magpie (*Pica candata*), on the other hand, though shy and wary in the British Isles, where gamekeepers wage a constant war against it, would naturally frequent the habitations of man. It is not persecuted in Norway, and an English writer, speaking of it there, says, "The magpie is one of the most abundant as well as the most attractive of Norwegian birds. Noted for its shy, cunning habits here" [in England], "its altered demeanour there is the more remarkable. It is on the most familiar terms with the inhabitants, picking close about the doors and sometimes walking inside their houses. It abounds in the Town of Drontheim, making its nest upon the churches and warehouses. We saw as many as a dozen of them at one time seated upon the gravestones of the churchyard. Few farmhouses are without several of them breeding under the eaves, their nests supported by the spout." As the magpie eats young birds, here is the bird to keep the sparrows' numbers in check, for it will live in towns and close to dwellings—just the localities sparrows frequent. The magpie's appetite is omnivorous, and it is charged with at times killing weakly lambs, and varying its diet by partaking of grain and fruit; but I never at Home heard any complaints of this bird from the farmers, whilst the gamekeepers had not a good word for it. The bird will eat carrion, so if one were disturbed taking a meal from a dead lamb it would probably be blamed for its death, which may have occurred from natural causes. Nor, I think, can there be much in the charge that it partakes of grain and fruit, otherwise it would not be such a favourite in Norway, nor so abundant as it is in France. If, however, it did take a little grain and fruit occasionally, the quantity consumed by it would not approach what would have been eaten by the sparrows, greenfinches, and blackbirds which had been destroyed by the magpie. If it did get too numerous, being a good-sized and conspicuous bird it would not be difficult for the bird-catchers to reduce its numbers. It is, in my opinion, the best bird to introduce to cope with the sparrow plague.

Some one or more of the shrikes would also be desirable acquisitions, and against none of them could even a suggestion of evil-doing be made; the only objection to which some of

the species might be open would be that they might devote too much attention to insects and neglect the sparrows. Nor are they likely to become such familiar friends as do the magpies in Norway. In the American pamphlet already referred to several of the correspondents write in praise of the shrike, of which the following example will suffice: Mr. H. K. Coale, writing from Chicago, says, "The northern shrike (*Lanius borealis*) feeds on them (sparrows) all winter." Mr. Barrows, the author of the pamphlet, in writing of natural enemies, says, "Probably the most useful bird in this respect is the northern shrike, which visits most of our northern cities in winter and feeds freely on the sparrow. At one time this shrike became so abundant on the Common and in the Public Gardens in Boston that it threatened to destroy all the sparrows, but the short-sighted authorities kept a man busy in shooting the shrikes until several dozen had been killed, and the useless sparrows were considered safe." From the nature of the migrations of the shrike referred to I fear it would not be suitable for New Zealand. There is another American shrike of less migratory habits, the loggerhead (*Lanius ludovicianus*), though it moves to the southward in winter; but it is smaller, and, though it eats birds, the greater proportion of its food consists of insects, of which the great majority are of an injurious character. The great grey shrike (*Lanius excubitor*), which is found in almost every European country, a large part of Asia, and northern Africa, and is an occasional visitant to England, would be more suitable. It is also more or less migratory, but as it is found in France at all seasons of the year it would probably find the climate of New Zealand equally suited to its requirements. It, however, frequents woods and forests in the summer, and only visits the more open districts in the winter. It would therefore be more likely to exterminate our native woodland birds than the sparrow. The most likely bird of the shrike family is the red-backed shrike (*Lanius colluris*). This bird has a wide range, being met with as far north as Norway and as far south as Cape Colony. It rarely visits Britain. It is often known as the butcher-bird, and is very predatory in its habits. It lives largely on insects, as well as small birds and animals. Dr. Brehm says, "It often continues to kill long after it has satisfied the cravings of hunger, and pursues small quadrupeds or birds so incessantly as to drive away or destroy all such as have been unfortunate enough to make their homes in its vicinity." The woodchat (*Lanius rufus*) is a summer visitor to southern Europe from Africa, and it is also found at the Cape. Its habits are similar to those of the red-backed shrike, but apparently its chief diet is insects in all stages, and worms,

and it only captures birds when its ordinary food is scarce. It is also migratory, and does not, on the whole, seem very suitable. I merely mention it as it could be procured from Cape Colony. The range of climate in New Zealand would probably be sufficient for both these two last-named birds, but the grey shrike seems to have the advantage of being the least migratory. The easiest to introduce into this colony would be the red-backed shrike, as, being obtainable from Cape Colony, only a short voyage would be required, and the tropics would not have to be crossed. It makes an interesting cage bird, as it has wonderful powers of imitation.

To sum up, I may say that, while I do not advocate the stoppage of poisoning operations, I think that the money spent in paying for heads and eggs could be laid out to much greater advantage, and I recommend the introduction of the magpie and the long-eared and tawny owls and red-backed shrike, or some of them, but especially the magpie. I may add that I think the long-tailed native cuckoo (*Eudynamis taitensis*) should be protected by law, as it destroys the eggs and young of other birds, and, as it is a conspicuous object when it visits any populous neighbourhood, it usually falls a victim to some random gunner.

Just a word regarding the existing law, and I have done. "The Birds Nuisance Act, 1902," imposes on the local authorities in the Middle Island the duty of destroying injurious birds from a day to be fixed by the Governor in Council. The birds to be deemed injurious are to be determined by the same authority. Districts may be proclaimed embracing within their borders the areas managed by several local authorities, and in such case the Act provides for a conference of delegates from each local authority being held for the purpose of recommending to the Governor a suitable day on which the work of destroying injurious birds should commence, and the methods that should be employed by each local body. To my mind there is too much "machinery" about the Act for it to be easily set in motion; and, as the Act provides for the appointment of the inevitable Inspectors and the making of regulations, I fear the amount of red tape about it would clog its action. The suggestion I have already made—that each county should be bound to employ a bird-catcher—would be a very much simpler and less costly method. No Inspectors would be required, as every farmer who suffered from the depredations of birds would complain to the County Council, and take care that the bird-catcher was zealous in the performance of his duties.

The idea in the statute that declaration of war should be proclaimed on a certain day—I assume, in each year—seems to me a very mistaken one. That we shall ever get rid of the

sparrow or the green linnet is not, I fear, to be expected, but that the plague can be kept under control so as to cease to be a serious matter I firmly believe. That can be accomplished, however, by no spasmodic efforts, but by waging the war against the small depredators at all times and seasons from year's end to year's end. Bad as things are now, they will become worse unless some really systematic efforts are made to combat the pest. Miss Ormerod and Mr. Tegetmeier, speaking of the extent of the damage done by sparrows in England, say, "The amount of the national loss by reason of ravaged crops and serviceable birds driven away may be estimated without fear of exaggeration at from one to two millions a year." What our own losses are no one can tell, but they must already amount to a very large sum. As regards the introduction of the natural enemies, that is a matter which would best be undertaken by the Government.

I may, in conclusion, refer to an objection that some will raise to our introducing any predatory birds into the colony. Such people will say, "Look at the introduction of stoats and weasels to kill the rabbits; our interesting ground-feeding birds are gone, while the rabbit still flourishes! So will it be if such birds as you advocate are introduced; our dwindling band of native songsters will disappear, while the perky sparrow will still thrive and multiply." To such I would reply that none would mourn the loss of our native birds more than I should, but the situation demands the risk. Every schoolboy who has gone bird-nesting knows that the nests of our native birds are much more difficult to find than those of the imported birds, and I doubt not that the magpie or shrike would find enough of the clumsy conspicuous nests of the sparrows or the easily-discoverable nests of the blackbirds and thrushes to supply their requirements with little trouble to themselves, so that the scarcer and better-hidden nests of our native birds would generally escape.

Since the foregoing was written a Proclamation has been issued under the Birds Nuisance Act dividing the South Island into eight districts, and declaring the house-sparrow, yellowhammer, and greenfinch to be injurious birds. The first and the last named are rightly placed in that category, but the second is not, so far as I am aware, numerous anywhere in the colony; and, if it were, I do not think it would ever become a nuisance —at least, it was not, like the green linnet and sparrow, looked on as an injurious bird in Britain when I was a boy. A few yellowhammers (*Emberiza citronella*) were turned out here in the early days of acclimatisation, and though they throve for a time they eventually died out. At the same time the cirl bunting (*Emberiza cirlus*) was introduced, and increased much

more rapidly than the yellowhammer. It has disappeared from this neighbourhood, but is still to be met with in the country, and as it is a much more active bird, and is destructive in its habits, I believe this to be the bird at which the Proclamation was intended to be aimed. Though the two birds bear some resemblance to one another in plumage, no one with any knowledge of British birds could mistake the one for the other, and the pleasing plaintive little song of the yellowhammer is most distinctive, and it may still be heard in some parts of the colony. This is, however, a trivial matter compared with the failure of the conferences to even forecast any benefits to be derived from the Act. There was abundant evidence of the futility of the whole affair, and the delegates seemed to be fully aware of the fact. Some showed this by abstaining from attending: at Dunedin a delegate characterized the whole affair as "unworkable," but said "it had to be seen through"; while in some conferences the resolution arrived at was that the destruction of the birds should be left in the hands of the Government. The Timaru conference resolved "that the Government be asked to offer a bonus of £500 for the most effective method of dealing with the small-bird pest," thereby showing their utter want of confidence in the present Act, and their hopelessness of experiencing any beneficial results therefrom, at the same time indicating their opinion of the importance of the question and the necessity for grappling with the problem in an effective manner.

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Art. VI.—*Note on the Veracity of the Returns of Age in the Census of 1901.*

By H. W. Segar, M.A., Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 6th July, 1903.*]

Plates IV. and V.

The statistics of the ages of the people afforded by census returns are marred by an element of uncertainty due to the ignorance, carelessness, and wilful misrepresentation of individuals. A person ignorant of his own age, ignorant of and careless in ascertaining the ages of members of his household, or wilfully misrepresenting the age of himself or the ages of others, is very apt to choose numbers ending in 0 or 5. Many, for instance, knowing an age to be about 40, will put it down in a round number as 40 without further bother. The result is that in census returns generally we find a greater number of people returned as being of such ages than is consistent with the numbers returned for neighbouring ages, as is shown in the following table: —

Table I.—Number of People returned at certain Ages in New Zealand Census, 1896.

Ages.	Number of People.	Ages.	Number of People.
39–40	7,224	49–50	4,926
40–41	**10,186**	50–51	**7,909**
41–42	5,556	51–52	4,092
44–45	5,751	54–55	5,285
45–46	**7,676**	55–56	**5,699**
46–47	5,741	56–57	5,562

Here the numbers recorded as being of ages 40, 45, 50, and 55 are evidently in excess of what should be.

The numbers ending in 0 are more patronised than those ending in 5. Also, numbers ending in 2 and in 8 are favourites in the same way, but to a much less extent. The result is that at these ages, and especially at those which are multiples of 10, we have clusters, as it were, of population in the census returns of ages, and corresponding deficiencies in the other ages. Now, as a matter of fact, in all populations that have not been subject to some very remarkable and unusual event that would tend to increase or diminish

the number of people at particular ages above or below the normal, the number of people at the several ages should change gradually and continuously from age to age. If the population be grouped into quinquennial age-periods, we find that the numbers in the successive age-periods do change in this manner.

Figs. 1, 2, illustrate these remarks by the graphical method. Fig. 1 gives the line which represents the numbers returned at the several ages from 20 to 80 years in the census of 1896, and also a similar line constructed by taking for the central year of each quinquennial age-period the average population of each year of age in that period. The ordinates for these averages are measured along those corresponding to the central years—namely, those ending in 2 or 7. Fig. 2 illustrates similarly the results of the census of 1901.

The curve given by taking the population in quinquennial age-periods offers a great contrast to the other. The absence of any pronounced angular projections indicates the absence of any serious tendency for the ages of people to be entered in special quinquennial periods. The population, then, as arranged in quinquennial age-periods may be taken as being practically correct, and the corresponding curve gives us a fair average curve with which to compare the other. The excesses entered in special years are consequently seen in each case to be drawn in the main from the neighbouring years.

A comparison of the lines for the two census years shows at once a remarkable resemblance in the forms of the lines representing the population recorded according to each year of age, indicating a remarkable general persistence in the tendencies we are considering. The variations from the average are very small until the age of 20 is reached, and this is why the figures are taken only as beginning at that equation. The variations are not considerable until the age of 30 years, and are greatest, relatively to the population of the age concerned, at 50 and 60 years.

A careful comparison of the two diagrams will make it obvious that in 1901 the variations due to erroneous returns of age were considerably less than in the previous census. We say a *careful* comparison because the mere magnitudes of the variations do not, as a rule, differ greatly in the two cases; it is the variations relatively to the population at each age that differ considerably. If the number of erroneous returns made in 1901 were proportionate to those of 1896 they ought, absolutely considered, to be much greater, because of the much greater population between the ages 20 and 80 years in the later of the two years. This point is also illustrated in the following table, which takes the populations returned at

each year of age ending in 5 or 0 and compares them with the means of the numbers returned for the two neighbouring ages in each case. The percentages of excess are then given.

Table II.—Veracity of Census Returns of Age.

Age.	1896.			1901.		
	Mean of Numbers of Adjacent Ages.	Number of Age specified.	Percentage of Excess.	Mean of Numbers of Adjacent Ages.	Number of Age specified.	Percentage of Excess.
20	14,961	14,850	−0·7	16,898	17,142	1·4
25	12,919	13,266	2·7	15,158	15,266	0·7
30	9,100	12,079	32·7	11,337	14,682	29·5
35	8,373	9,226	10·1	9,840	10,287	4·5
40	6,390	10,186	59·4	7,316	10,735	51·7
45	5,746	7,676	33·6	6,617	8,044	21·6
50	4,509	7,909	75·4	5,133	8,134	58·4
55	5,424	5,699	5·1	4,784	4,949	3·4
60	3,048	5,445	78·6	3,883	5,965	53·1
65	2,419	3,038	25·6	3,580	4,095	14·4
70	1,172	1,763	50·4	1,896	2,662	40·4
75	873	927	6·2	1,100	1,157	5·2
80	290	414	42·8	466	550	18·0

It will be noticed in this table that in every case, except for the age of 20, there is a diminution in the percentage of excess, that in the majority of cases this diminution is considerable, and that in the one case in which there is an increase the excess in both censuses is only very small. Such small excesses, moreover, should be ignored, as they are no greater than the variations in the annual number of births.

The above is but a rough method of dealing with the question, but it is really sufficient for the purpose in hand, as the reductions are so considerable. As, however, the excess is measured for any year from the mean of the recorded populations of the two neighbouring years, which are themselves less than the true populations of those years, the excess obtained is not the excess of the recorded population over the true population for the year of age under consideration, but is considerably greater than it. The diminution of the one excess involves, however, a somewhat proportional diminution in the other, and so the above argument is not vitiated, although we must not take the percentages of Table II. as measuring the proportion of erroneous returns for the several years of age.

There is another way of approaching the problem. The census tables, giving the numbers recorded at each age, may be adjusted by distributing the total numbers in certain groups of ages over the single years according to actuarial laws and methods. This has been done by the Actuary of the Government Life Insurance Department for the last two censuses, and the results are recorded, not in the ordinary census volumes, but in the reports of the Registrar-General on the same. Table III., following, takes for both censuses these adjusted numbers, compares with them the recorded numbers, and presents the excess as a percentage, the ages considered being from 20 to 75, at which latter age the tables of the Government Actuary cease.

TABLE III.—VERACITY OF CENSUS RETURNS OF AGE.

Age.	1896.			1901.		
	Adjusted Population at Ages specified.	Recorded Population at Ages specified.	Per-centage of Excess.	Adjusted Population at Ages specified.	Recorded Population at Ages specified.	Per-centage of Excess.
20	14,755	14,850	0·7	16,725	17,142	2·5
25	12,620	13,266	5·1	15,254	15,266	0·1
30	9,975	12,079	21·1	12,199	14,682	20·4
35	8,359	9,226	10·4	9,963	10,287	3·3
40	7,545	10,186	35·0	8,245	10,735	30·2
45	6,150	7,676	24·8	7,161	8,044	12·3
50	5,708	7,909	38·6	5,847	8,134	39·1
55	5,085	5,699	12·1	4,963	4,949	−0·3
60	3,845	5,445	41·6	4,451	5,965	34·0
65	2,565	3,038	18·4	3,728	4,095	9·8
70	1,390	1,763	26·9	2,248	2,662	18·4
75	750	927	23·6	1,083	1,157	6·8

As was to be expected, the percentages of excess in this table are smaller than in Table II. They give a reasonably accurate estimate of the proportions of the returns, at the several ages considered, that are erroneous. Comparing the results for the two censuses, we get the same general result as before; in every case but two there is a reduction, and generally this reduction is considerable. The two exceptions consist of the age of 20—and in this case the percentages of excess are small in both censuses—and the age of 50—and in this case, although the percentage of excess is large in both census years, the increase in the later year is very small.

Thus the fact is conclusively established that in the recent census there was a much greater approach to truth in the

returns of age than in the preceding census. It would have been of interest to have considered some earlier censuses and found what the tendency was in this matter in earlier times, but the census returns prior to 1896 do not give the population for each year of age, and it is impossible to pursue the question.

As to what the reasons are—and such must exist—for this very substantial and satisfactory progress we cannot suggest anything with confidence. Countries differ very much in the matter we have been discussing, and on the whole the better the education of the people the more truthful are their returns of age. In India, on the one hand, the returns reach the height of the ridiculous; in 1890, for instance, out of 100,000 persons of all ages, the number returned as of 39 years was 322, and of 41 years was 216, while the number returned as of 40 years was no less than 5,240! In Germany, on the other hand, the results are far better than our own. One can hardly claim, however, that the education of the people of New Zealand has improved in five years to such an extent as would be necessary to explain the phenomenon. If the improvement I have pointed out were confined to or more conspicuous in the older ages, the influence of the old-age pension scheme, that has made many an old person better acquainted with his age, and would be likely to make him more precise in recording it, might be put forward as a main cause, but the improvement is about equally conspicuous on the whole throughout the period from 30 to 80 years of age. Of course, a higher moral sense in the people would suffice to explain everything; let us hope this is the true cause.

I have calculated tables for the sexes taken separately similar to those discussed above, but which I do not propose to publish. They reveal the fact that there is, on the whole, nothing much to choose between the sexes in the matter of inaccurate returns of age, in spite of the fact that the chief blame for this offence is popularly given to females. If females are more strongly tempted from motives of vanity to make inaccurate returns, it may be that a finer moral sense prevents them yielding to the temptation to any greater extent than the males. But, however the causes of such inaccuracies may differ in kind or in degree in the two sexes, the results in the main are the same. A greater preference in the males than in the females for the ages 35 and 45, and a greater preference in the females than in the males for the ages of 50, 60, and 70, are apparently the only decided differences that the tables reveal.

ART. VII.—*On certain Decimal and Metrical Fallacies.*

By R. COUPLAND HARDING.

[*Read before the Wellington Philosophical Society, 5th August and 7th October, 1903.*]

IF there be one quality more than another that distinguishes the scientific from the unscientific mind it might well be defined as the ability, or, perhaps more correctly, the habit, of discriminating clearly between the symbol and the thing signified. Symbols, indispensable though they be, are always more or less defective representives of truth, and are full of danger, when, instead of servants, they become masters and dominate the thoughts of men. They give rise to a multitudinous brood of fallacies, and fallacies as they gradually develop ripen into positive evil. In theology the exaltation of the symbol becomes idolatry, with intellectual darkness, moral corruption, and spiritual death: in science it may be found elevating the latest convenient working-hypothesis into an established law of nature, when that which was at one time helpful becomes injurious. Truths appeal to the higher intellectual faculties, and can be appreciated only by application and study; symbols may be memorised by rote and acquired with slight trouble—they are nothing more than counters, though only too easily mistaken for genuine currency. Truths grow by accretion; symbols remain unchanged, and when outgrown they are a check on progress. Of this fact schemes of notation afford sufficient proof. Our English tongue, the world-language of the future, is cruelly hampered in its conquering course by a defective notation—not only inadequate, but the type of all that is etymologically and phonetically misleading. A thousand years ago our Saxon ancestors had something like a scientific and consistent orthography—a living system, adapted to its purpose. To-day we find a living language imprisoned in a dead alphabet. The symbol is outgrown. Musical notation affords another, though less extreme, instance. A very slight change would convert a system at present perplexing and inconsistent into one consistent and helpful; but again progress is fettered by the outworn symbol. Our arithmetical notation, happily, is free from the absurdities attaching to musical and orthographic notation. If, for example, the symbol 5 might under certain arbitrary rules signify the same as 32, 41, or 55, if it was sometimes to be read as 7, and occasionally, being "silent," had to be ignored altogether—if the interpolation of another symbol having sometimes a negative and sometimes a positive value made it equal to 6—then our

arithmetical notation would be fairly comparable with our orthography, and computation would be as difficult as English spelling.

But it is quite easy to be in bondage to arithmetical notation. Thousands of folk skilled in computation, using figures daily, confound them with the things they represent, never realising that after all they are merely counters — symbols, perfect and efficient within their own very limited range, but representing in reality only a convention, and no solid fact. The mathematician knows their place and their limitations; the mere computer, finding them ready to his hand, imagines them to be rooted in the very nature of things. He knows, for example, some of the curious properties of the number 9, but would be unable to discriminate between the inherent properties of that number—those, for example, which are peculiar to the square of 3, and which no notational system could affect—and those other qualities which are accidental and notational, and would be transferred to another number were any other radix substituted for that of ten.

This is a point of basic importance in the consideration of the subject of any proposed change in measures and weights, and especially when a change of standard is involved. The subject is of practical importance now, when the foreign system, already permissive, has advanced another stage in our Parliament, and will, unless resistance is offered, displace in a few years—legally if not actually—our Imperial standards. There has been no popular demand for the change; there is absolutely no popular discontent with our present standards; but an active minority has carried its point so far, as agitators can—without public sympathy or approval, but in the face of that massive apathy and general indifference to any change that does not threaten some immediate loss or disability. And it is noteworthy that the arguments urged in support of the change appeal to popular notational fallacies rather than to mathematical facts or scientific truths.

Of late years we have seen, at annual meetings of Institutes of Accountants, Chambers of Commerce, and similar bodies, formal resolutions passed on the subject as casually and perfunctorily as the vote of thanks to the chairman. In our own Parliament during the current session a Bill, further-reaching in its effects (should it ever become effective) and more revolutionary in its scope than any legislation ever before proposed in this colony, passed its preliminary stages with less notice than is sometimes given to a fifty-pound item on the estimates. It does not seem unreasonable to infer that those who deal thus lightly with grave matters have neither studied them nor realised their importance. They know that our system of money-computation is defective and causes unneces-

sary waste of time, and when they are told that "the decimal system" will set everything right they do not investigate for themselves. The onus of proof lies with the aggressive minority, and that proof is not forthcoming. They offer instead of proof many assertions which will not bear examination.

The initial fallacy is to call the French scheme "the" decimal system. It is a decimal scheme, as are also other and better schemes. Its one distinguishing feature is its unit—the meter. It is therefore not "the decimal system," but the "metric" system. The misnomer gives rise to the inference—and the notion is widely held—that decimalisation involves a change of standards, which is not the case. There can be no warrant for so radical a change except it be plainly shown—

(1) That the standard proposed is scientifically or practically better intrinsically or extrinsically than the existing one;

(2) That the advantage is so great as to outweigh the disturbance and inconvenience occasioned by the change.

I do not think that these propositions can be seriously disputed. If, then, it can be proved—

(1) That the meter is arbitrary, possessing no scientific value nor any ascertainable relation to anything in creation;

(2) That the national standards possess these qualities in a high degree;

(3) That for practical purposes the existing standards are essentially better and more convenient—

what excuse is there for the change? And there is overwhelming proof in support of these propositions.

I have spoken of the resolutions of certain bodies in favour of the change as perfunctory. It is significant that almost immediately after the last formal resolution of the Wellington Chamber of Commerce the chairman wrote to the press pointing out that the change, if made, would have serious and unlooked-for consequences. Yet these consequences must surely suggest themselves to any one who gives the matter any consideration.

As for the decimalisation of the national coinage, it has long been a desideratum. A suggestion was lately made to divide the pound sterling into four hundred parts. It was put forward as "decimalisation of the coinage," which it is not. The subject has been fully dealt with by a commission of leading mathematicians in Britain, and a complete and consistent scheme was long ago formulated. The figure representing the number of pounds would be followed by three figures separated by a space or decimal point, and

representing respectively "florins," "cents," and "mils." The first step was actually taken in 1849, when the florin was coined, and the complete reform would undoubtedly have been carried out and extended to weights and measures also as far as practicable but for the opposition of the "metric" party, who have regularly blocked any systematic reform of the national measures. They have realised throughout that with a rational coinage system the crusade against the national standards would be almost hopeless.

They invariably lump together the present coinage system, which is indefensible, with the standards of weight and measure, and draw a supposed parallel. But the imaginary parallel is a fallacy. Weights and measures deal with entities and qualities outside our own control. Whether we weigh a load of ballast or compute the distance of a star we are engaged in investigating realities—relations and interrelations between ourselves and the universe without—and must adapt our methods, as conveniently as we may, to things as we find them. Coinage, on the other hand, is entirely artificial. From first to last the form it takes is under our own control; it should be adapted to the radix of computation. Our coinage is not so adapted, and to that extent is irrational. Further, it conforms only very imperfectly to weight and measure standards. We need not go further than to America for a practical example. In the United States and Canada the coinage has been decimalised, the weights and measures remaining unaltered.

We come now to perhaps the greatest and most audacious of the fallacies propounded by the advocates of the meter. We find it stated that it would save so much of the time at present given to the study of arithmetic as would amount to a complete revolution. Last year it was asserted by an Australian writer that "compound calculations would be no longer necessary, and need not be taught in schools." Children, he said, were "kept at school learning arithmetic from one to two years unnecessarily because of archaic and antiquated rules and clumsy and involved methods." Every mathematician, every qualified teacher, knows that this is not the truth. Every one engaged in any kind of calculation has necessarily to deal with varying ratios; one of the chief purposes of the study of arithmetic is to qualify us to equate them, and it is to assist us in this work that artificially fixed standards are required. Fallacious as the assertion is, it is the stock plea of the metrists. It is the argument of the spelling-reformers borrowed and misapplied. Years of school life are wasted in learning by rote archaic and outworn forms of spelling—forms which misrepresent and caricature our speech; but what chance would a Bill for reforming ortho-

graphy have in Parliament? What New Zealand Chamber of Commerce has ever urged the necessity of rational spelling? Yet this colony has as much right to lead in the one direction as in the other, and the gain orthographic reform would bring would be incalculable. In this respect, however, prejudice is so strong that the Education Department insists on retaining corrupt forms that have largely died out in common use. It clings tenaciously to the intrusive "u" in "honour," "labour," and even in "neighbour." It was not without surprise that I saw in the Weights and Measures Bill of 1903 even such a concession to systematic spelling as "meter." By the way, it seems curious that this little colony should strain the "silken thread" by endeavouring to initiate a change that should begin at the centre of the nation's commerce. It can scarcely expect to force the hand of the Empire in a matter like this. In fact, should our Parliament attempt to give effect to the proposal it would have enough to do for many years to come in forcing its acceptance upon the people of the colony.

We have been persistently told that the metric system is scientific. It professes to be, but the claim is based on fallacy. Not only is it found on examination to break down in this respect at nearly every point, but on purely scientific grounds as on practical it compares unfavourably with the national standards. It was itself the outcome of a period of social and scientific delirium, and its history to the present day is a record of practical inadequacy and of bureaucratic coercion.

Up to the last decade of the eighteenth century European weights and measures, though exhibiting appreciable variation in standard and still encumbered with obsolescent tables applying only to specific industries or localities, were practically uniform in principle. The standard of measure was the foot, duodecimally divided. In England the inch was also divided into twelve, and the twelfth-inch, known as the "line," was used chiefly in scientific measurements. It is the unit known to printers as "nonpareil," or in present nomenclature "six-point." The third-inch, equal to four lines, was the lowest unit popularly recognised, and was known as the "barleycorn," as it was supposed to be fairly represented by the length of a grain of barley from the centre of the ear. Old table-books still in use in my childhood began, not as might reasonably have been expected, "Twelve lines equal one inch," but "Three barleycorns, one inch." Some idle jocosity has been indulged in on the assumption that an actual barleycorn was the ultimate basis of Saxon measurement, but this is a fallacy. The popular name of every measure, without exception, refers the standard to some supposed natural equivalent. In weight, for instance, we have the "grain." No

people were more strict in the matter of standards than the Saxons. They had a practical and scientific system; their monarchs made it a matter of duty to see that no corruptions or deviations took place, and the British measures have been so closely guarded that after a thousand years the divergence is so slight as only to be detected by very accurate measurements. In France, as in England, the foot was divided into twelve inches, and the inch into twelve lines, and the line again into six, and this last subdivision, of $\frac{1}{72}$-inch, was called the "point." Whether the point was also recognised in Britain I do not know; it is now, and as it is the basis of all printers' measurements it is usually known as the "typographical point." As it is not minute enough for all purposes, the half-point difference is recognised in the smaller types, so that in systematic type-measurement, which is exactly the same in principle (though not in standard) all the world over, the old national measures are retained, in which the duodecimal subdivision is consistently followed throughout:—

12 half-points = 1 line.
12 lines = 1 inch.
12 inches = 1 foot.

The French standard was larger than the English in the proportion approximately of 555 to 517, and the Continental and British type-standards differ respectively to-day in the same proportion.*

A like agreement in principle with diversity of standard prevailed in regard to weights for ordinary purposes, the pound being divided by the simplest series of all—2, 4, 8, 16. The larger measures and weights were varying multiples, more or less systematic, some local, others adapted to special purposes only, and many of limited application, obsolete, or nearly so. A uniform principle underlying so much divergence in detail might have suggested a reason, and possibly a good reason, for its retention. Scientific reformers would have inquired if such reason existed; for with uniformity of principle already to their hand nothing more was required to establish an international system than the harmonizing and unification of the standards of measure and weight, which could have been accomplished with a minimum disturbance of

* Theoretically. The systematization of type was seriously taken in hand in the United States some years ago, and is now in general use. At first the national standard was taken, but the vested interests of large houses working on an inaccurate system prevailed, leading to a departure from the true standard, which, though infinitesimal and ignored in all ordinary reckoning, is greatly to be regretted. The precise divergence between the American type-standard and the British Imperial standard is 0·005 inch in the foot, the typographical inch as at present defined therefore equalling 0·999583 of the standard inch.

local prejudices, for the changes as they applied to any given locality would scarcely have been noticed, while the advantages would speedily have made themselves manifest. But no such inquiry was made. The accidental discrepancies were magnified, the underlying principles ignored, just as they are by the metrists of to-day, and a bran-new scheme must be devised—one which, as it was to supersede all others and last for all time, must be nothing less than perfect.

In that strange period of unrest the judicial faculty seemed to be completely suspended; the scientific spirit, which breathes only in an atmosphere of humility, was dead. Truth-seekers there were none, for there remained no truth to seek. Carlyle, in his trenchant style, has pictured the utter intellectual barrenness of the time, and the absence of the creative faculty—the scientists who made no discovery, the ingenious men who brought forth no invention. In every department, theoretical or practical—in science, philosophy, politics, or morals—empty symbols took the place of realities, fallacies of facts. Miss Clerke, in a late article in *Knowledge*, has eloquently described the self-sufficient "science" of the time:—

> There were no more worlds to conquer. . . . Nature for the moment submitted readily to the trammels put upon her by human thought; her intricacies no longer seemed to defy unravelment; her modes of procedure looked straightforward and intelligible. . . . It was an epoch of peremptory renewals. The formula of equality promised to regenerate society; a political panacea had been found by the creation of a republic "one and indivisible," and the success of the guillotine in securing its supremacy was almost outdone by the triumphs of the calculus in vindicating the unimpeded sway of gravitation.

In this spirit—the antithesis of the scientific spirit—the task was undertaken. The result was a comedy of blunders to which the history of science can scarcely furnish a parallel.

The unit of measurement was necessarily the foundation of the entire system. The reformers had to their hand the ancient foot of France with its authoritative standards; they had access to the corresponding measures of Europe, from which, had they chosen, they might have deduced an average. But *their* unit must be new. Destined to be universal, it must be earth-commensurable. It must at the same time be unmistakably and indisputably French. So at great expense and with enormous labour they measured an arc of the meridian passing through France, divided the quadrant of the meridian thus deduced into ten million parts—that is, a forty-millionth of the entire circle—and this unit is the *mètre*.

Note, first, the initial blunder—denounced by Herschel as "a scientific sin"—the choice of a curve as the basis of rectilinear measurement. The fact that the curve was on so large a scale that its true form was inappreciable to the senses does

not affect the question. To treat it as a right line was inexcusable on the part of men professing to institute a scientific reform in a scientific way. They based their whole fabric on a fundamental fallacy, consciously and deliberately, without even the excuse of ignorance. Note, too, that an arc of the meridian—unless it be one like that of Greenwich Observatory, selected by common consent as a starting-point —has no significance, and even in such an exceptional case its significance is only arbitrary and factitious. The meridians of a sphere are infinite in number, and unless the sphere is geometrically perfect are not uniform. The degrees of the terrestrial meridians vary in length from 66·91 to 69·40 miles. Note, too, that the standard, if lost, could never be restored by a repetition of the original process. Variations in the result inevitably appear on remeasurement, however exact, and this particular measurement was exceptionally difficult. As it was, the result was soon found to be appreciably wrong. The error is now stated to be 4,008 ft. So that the new universal earth-commensurable and French unit proved, after all the trouble and expense lavished upon it, to be arbitrary—to possess no more intrinsic significance than the length of a random straw picked up in the harvest-field. It may be said—it has been said, since the insignificance of the standard cannot be disputed—"No matter, so long as the standard is there and is recognised."* But it is evident that a really scientific standard must have significance. The reformers must have realised this, else why all this costly and elaborate preliminary parade of earth-measurement? Why inconvenience a whole nation for a hundred years when the ancient *toise*, divided and multiplied by ten, would have

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* An old article in the *Athenæum*, referring to the erroneous measurements on which the standard was based, said, "An error of $\frac{1}{200}$ inch in the determination of the *mètre* is more than counterbalanced by the extreme simplicity, symmetry, and convenience of the metric system. Professor Bessel observed in respect to the *mètre* that, in the measurement of a length between two points on the surface of the earth, there is no advantage at all in proving the relation of the measured distance to a quadrant of the meridian. Professor Miller, of Cambridge, who quotes this remark, deems the error in the relation of the *mètre* to the quadrant of the meridian to be of no consequence; and he mentions another slight error in the metric system, discovered by recent research, and relating to the density of water, which he gives in the following words of Bessel: 'The *kilogramme* is not exactly the weight of a cubic *décimètre* of water. Many of the late weighings show that water at its maximum density has different density from that assumed by the French philosophers who prepared the original standard of the *kilogramme;* but nobody wishes to alter the standard of the *gramme* on that account.'" So that while the defects, real or imagined, of the British system are proclaimed and paraded by metrists, the acknowledged errors in the French scheme, fundamental or co-ordinate, are "of no consequence."

answered every purpose of the *mètre*, and have saved, in the full literal sense of the words, a world of trouble?

In a pamphlet published seventeen years ago Mr. Christopher Giles, of Adelaide, thus summed up the "scientific" foundation of the whole system :—

> Based on a curve—therefore unscientific in theory.
> Arbitrary—therefore wanting in scientific significance.
> Non-earth commensurable.
> Devoid of universality, in origin, genius, and fact.

It does not seem to be as generally known as it should be that our own much-criticized scheme of lineal measurement—the origin of which is too remote to be traced—is scientifically sound on all the points where its modern rival is so conspicuously defective.

Some may imagine that the yoke imposed on France was a light one. On the contrary, it was not the least oppressive of the many terrible *sequelæ* of the Revolution, and it was imposed only against stout resistance and with much utterly unnecessary agony. The system is permissive in the British dominions, and so long as it is only permissive and the national standards are in free and general use no very active opposition is likely to be offered. In India, though an Act was passed in 1870 substituting the metric for the national standard, and the law still stands unrepealed, it is a dead letter. In the United States a strong organization has been formed "for preserving and protecting our Anglo-Saxon weights and measures." It keeps the subject before the public by means of literature and lectures, and sees that the metrist minority are met with counter-agitation. Some such institution appears to be needed in New Zealand.

In Great Britain, where Commission after Commission has investigated the subject, expert and scientific testimony has been strongly in opposition to the "reform." From astronomers and mathematicians of the highest repute it has met with unqualified opposition. I do not know of one who has pronounced in its favour. These are men of unquestioned scientific standing: men, moreover, trained to consider realities rather than symbols, and the relations of things rather than the mere notation by which such relations are expressed. The leading British daily paper is a consistent opponent of the metric change, and the *Times*, in dealing editorially with a scientific question, may be trusted to have the best scientific advice available.

By whom is the change advocated? Chiefly by computers, who, as is well known, are not necessarily mathematicians. Computation is not an intellectual but a mechanical operation. There is no kind of computation that cannot be performed more efficiently and quickly by a machine than by a human

brain. As regards money-reckoning, the computer has a genuine grievance and a good case; but a coinage reform need not disturb the standard weights and measures.

There is one important department of science—that embracing chemistry and physics—the practitioners of which are inclined to look favourably on the proposed change. Their work involves electrical measurements, and the only standard available is affiliated to the meter. It is not that any intrinsic merit can be claimed for the system itself—its nomenclature is a linguistic horror; but those engaged in branches of science where these measures are in use naturally prefer one system instead of two. It must be remembered, however, that the convenience of this limited class of workers would be gained at the cost of the inconvenience of other branches of scientific men, especially those concerned with celestial or terrestrial measurements, as well as of the disturbance of all existing systematic work by land and sea.

As against the *Times*, we find in the *Scotsman* an able newspaper advocate of the system. But the *Scotsman* admits that two generations would not suffice to carry the change into effect.

The stock arguments in favour of the meter, when examined, still further add to the monumental pile of fallacies. We are told, for example, that in our insular prejudice we are holding out against the peoples of the world—that our commerce is crippled by our unintelligible system. Statistics are adduced to show how many millions have adopted the meter, and how many Governments have legalised it as their standard. These statistics look formidable enough, but it shows a curious lack of proportion when insignificant principalities whose commerce is a negligible quantity are balanced against Powers such as Great Britain, the United States, and the Russian Empire. Comparative-population statistics are wonderfully inflated when wild tribes within European "spheres of influence" are counted in. Figures thus built up may seem imposing, but on applying reasonable tests we find fallacy once again.

The truth is the exact contrary. Among the educated, civilised, and progressive peoples of the world—and these alone are concerned in the question—the British-American standards are in use in the proportion of two to one, and a still larger proportion of the world's commerce is in the hands of the people who adhere to these standards. Two-thirds of the world's printed matter—two-thirds of the correspondence passing through the world's post-offices—is produced by English-speaking folk. This gives something like a fair test of the proportions involved. The suppression of the old European national standards leaves the British weights and

measures (with perhaps the single exception of the typographic standard, the decimalization of which is impossible) the sole rival of the meter, the sole representative of a system which has survived the vicissitudes of thousands of years, and which now is in a majority of more than two to one. Again to quote Mr. Giles, the inch-and-foot scale represents—

> The greatest amount of territory by land and sea.
> The highest rate of increase in population.
> The greatest wealth.
> The pre-eminence in commerce.
> The first place in extent and power of colonisation.
> The greatest freedom for its individuals.
> The first in philanthropy and improvement in the condition of subject races.

It is significant that no country has ever voluntarily adopted the meter. It has always been arbitrarily enforced upon the people—in Sicily literally at the bayonet-point. And even under the most rigidly repressive rule the old system often lingers. A writer in the London *Engineering World* only a few months ago stated that in Prussia, Hungary, Hamburg, and Hanover the "fuss" is still used in measurement, and that he could give other instances of the survival of the old standards.

In France, it is needless to say, there was no attempt to consult the people as to the change. It is instructive to read what Rees's Cyclopedia (1819) placed on record regarding the introduction of the scheme into that country :—

> That beautiful and scientific theory [this authority says] has not been found unexceptionable in practice. On the contrary, it met with such opposition on account of the Greek and Latin terms and the decimal division that in 1801 the Government allowed the people to use, for a limited time, their own vocabulary of names, applying them to the new standards, which are still retained. And in 1812 a further concession was made by the Imperial Government to the prejudices and habits of the people. They were allowed to continue the ancient vocabulary applied to the new standards with the word *usuel* added to each: thus, two *mètres* are the *toise usuelle;* half a kilogramme, the *livre usuelle*, &c.; and *these units are not divided decimally,* but into *halves*, *quarters*, and *eighths*. The long measures are also *divided duodecimally*. Besides the binary divison of weights, the *livre usuelle* is divided into ounces, gros, and grains, like the ancient *livre*, *poids de marc*. Hence the new ounce and its divisions depart so widely from the gramme that the proportion cannot be ascertained without a troublesome calculation. Thus, after more than twenty years of troublesome experiment and trial of the metrical system the only advantage that has been gained is that of establishing one common standard, the *mètre;* but uniformity might as well have been obtained by making the ancient *toise* (so universally known) their standard.

"Uniformity" being the avowed object, the change of the standard, with all the perplexities it involved, was, as the critic of the Cyclopedia recognised, unnecessary. The one remaining recommendation, then, of the metric system is its

decimal radix of weights and measures, universally applied. That certain advantages accrue from this unity of method is too obvious to admit of dispute; but they are far from making the system the perfect one its advocates represent it to be. Its perfection we are expected to take for granted. But, in view of what we are required to abandon in its favour, it is not only reasonable but necessary to inquire, Is it not possible to overrate the advantages of a universal decimal system?

This question brings us to first principles, to the base of the whole fabric—the system of notation and numeration in world-wide use. Is this system itself perfect, either practically or scientifically? It is as much an "accidental inheritance"—to quote Mr. Mattieu Williams's contemptuous designation of our national standards—as the standards themselves; but the reformers did not go to the root of the matter—they made no attempt to reform nor even, apparently, to investigate it. The fact that our numeral signs are called "the ten digits," and the further fact that in many languages the words "five" and "hand" are related, or even identical, associate our system with the primitive method of finger-tally as unmistakably as the verb "calculate" embodies the fact that pebbles were used in bygone days as instruments of reckoning. But, widespread, almost universal, as decimal calculation is and has been, ten has never been the sole radix in common use. In practical concerns it is the geometrical or tangible qualities of numbers with which we have to deal, and the geometrical defects of ten as a radix are a standing disqualification, with all its factitious advantages as the root of our notation. Were it possible for the world to start afresh—as the Frenchmen a hundred years ago dreamed of doing—mathematicians would certainly discard ten as a root-number and seek another, and that number would almost certainly be twelve. Had such a proposition come from the French scientists when the change was undertaken it would, even if ultimately found impracticable, have had good scientific reasons in its favour; in fact, the difficulties, great though they are, might not then have proved insurmountable.

Our arithmetical notation expresses actual numbers only from 1 to 9. Thenceforth, both in speech and writing, all numbers are indicated not as they are in themselves, but in their relation to the radix ten. So with fractions. Only those with a single numerator and denominator express actual relations to unity; beyond these the artificial element makes its appearance. Mr. R. T. Barbour, writing last year in an Australian review, remarked that, instead of vulgar and decimal fractions, we should say vulgar and natural. This is a good instance of a notational convention obscuring

genuine relations, for the suggestion that there is anything at all "natural" in decimal fractions, especially as contrasted with vulgar fractions, is a complete inversion of fact. Take that convenient school-book illustration the apple; halve and quarter it. Which form most correctly and naturally expresses the proportion the sections bear to the whole? The "half" or "quarter" represents the actual fact accurately expressed by the vulgar fraction, and by that alone. To describe the fruit as divided into sections of 0·5 or 0·25 is to introduce an artificial convention remote from the fact, warrantable only when, for purposes of calculation, we are considering the pieces in association with others actually divided into fifths, tenths, or twenty-fifths. The "Autocrat" has told how, after defending his landlady's pie, "I took more of it than was good for me—as much as 85°, I should think—and had an indigestion in consequence." This does not strike an appreciative reader as intended for the "natural" mode of expression, but rather as a piece of playful pedantry on the author's part. Vulgar fractions are so universally and unmistakably natural that no convention or notation, however ingenious, can dislodge them. Therefore the German typefounder of to-day, being a man of common-sense, catalogues his smaller wares by the "half-kilo." (his nearest approach to the discarded *pfund*), the American coins his half- and quarter-dollar, and so to the end of the chapter will weights and measures necessarily be popularly divided, thought of, and spoken of in halves and quarters, whatever official system may be in vogue, or by whatever written symbol these values are expressed.

The radix of 2 is one of the most important in practical use, and in many cases it is the only practicable one. It governs not only our own, but the other traditional systems of weights; it is the obvious corollary of any system of balancing. In book-folding it is in all ways the most convenient, and its sole rival, the sextuple fold, is almost extinct. The names "twelves" and "twenty-fours" are still in use to indicate certain shapes and sizes, but as a matter of practice such are nearly always now printed and folded as eights or sixteens. A "decimo" sheet would be an obvious impossibility. Two of the multiples of 2—eight and sixteen—have been suggested as notational substitutes for ten; but as an arithmetical radix either of them would be little, if any, better, apart from the consideration that one is inconveniently small and the other just as inconveniently large. The latter would further involve a cumbrous notation and an extensive nomenclature, as an American would-be reformer, who boldly selected sixteen as his radix, discovered many years ago. De Morgan, in his "Budget of Paradoxes," has made merry over

7—Trans.

the uncouth terms devised by this innovator; but if there had been any sound basis for the suggestion itself the professor would have treated the paradoxer more seriously.

A duodecimal scale has had numerous advocates, and a large amount of work has been done in the way of compiling tables, &c., in appropriate notation by isolated workers, many completely ignorant of the fact that others have gone and are going over the same ground. I have seen more than one publication on the subject. One of these, by Mr. Henry M. Parkhurst, an American mathematician, contains elaborate tables of logarithms, primary and secondary multiples, least divisors, &c., all calculated on the radix of twelve, and I understand that the author has much more matter of the same kind in manuscript. He uses X and Λ, contracted to the width of the other digits, to represent ten and eleven, and these two special characters give his tables a peculiar appearance. There is, or was, a Duodecimal Society in England, formed to bring about organized and united action, but I have never seen any of its publications, nor do I know its address. The most prominent duodecimalist, however, was the late Sir Isaac Pitman, who took up the subject with characteristic energy. His attention was directed to the matter through the agitation in and out of Parliament in favour of the metric system, among the defects of which he held that its decimalism was not the least. "With a view to carrying his proposal into practice," his biographer writes,* "new types were ordered (ƭ, ten, and ɛ, eleven) in four sizes, and it was Mr. Pitman's intention to employ the new notation in his *Journal*, and to recommend it for general adoption. During 1857–58 he counted everything as far as possible by dozens and grosses, with a view of paving the way for the new numeration; but he was unequal to the task of undertaking a reform of this magnitude in addition to the writing and spelling reform, and after a series of trials he reluctantly abandoned the project, but not without hope of seeing it inaugurated at some future period." For two years he used the notation in his *Journal*, and kept it up in his private accounts till 1862. His scheme included a coinage system — pence, shillings (a gold twelve-shilling-piece to take the place of the half-sovereign), and "bancos" = a gross of shillings. The figures "7ƭ3," with currency symbol prefixed, would thus represent seven "bancos," ten shillings, three pence. He probably proposed to reform current weights and measures on the same plan, but, not having access to the old *Journal* files,

* "A Biography of Isaac Pitman, Inventor of Phonography." By Thomas Allan Reed. London: Griffith, Farran, Okeden, and Welsh. 1890.

I have no details. The disturbance of measures by complete duodecimalisation would amount to no more than systematization, and would be comparatively slight, but it would have been otherwise with weights. It will be noted that a single radix would have governed arithmetical notation, measurement, and coinage.

To those who have any knowledge of the life and work of Isaac Pitman it is needless to say that he was the reverse of an idle dreamer. He was one of the most industrious, methodical, and practical of men, possessing extensive knowledge and an inventive mind. Without these qualities he would never have made the practical success he did of his system of phonography, which, on its own merits alone, dislodged every previous system of shorthand, and still holds its ground against all rivals. When he received his somewhat belated honours from royalty, they were generally approved as having been bestowed on a public benefactor. Any man who looks forward in advance of his time must bear the penalty of being ignorantly esteemed a paradoxer; but even in the field of spelling-reform, to which he devoted years of apparently fruitless toil and expense, his work has not been lost, for he has familiarised the millions who write shorthand with the idea of a rational alphabet, of which they make daily use. But the reform of arithmetical notation, however desirable in theory, seems to be too large a contract for any man, or even any nation, to undertake, and its foremost advocate was well advised to let it drop.

As notational signs the Pitman figures could scarcely be improved upon. While conforming in character to the familiar numerals, they can also be read as the initial letters of the words "ten" and "eleven" respectively. The following table of various numbers compared in the two notations gives an example of the symbols as they appear in actual use :—

Decimal.		Duodecimal.	Decimal.		Duodecimal.
12	=	10	287	=	1ƐƐ
22	=	1Ƨ	432	=	300
100	=	84	999	=	6Ɛ3
107	=	8Ɛ	1570	=	ƧƧƧ
144	=	100	1728	=	1000

Apart altogether from any theory of reform, a little practice in this notation is a remarkably illuminating exercise in arithmetic, showing, as it does, that the decimal system conceals more than it discloses of the properties of numbers. Awkward fractions disappear, while numerical relationships come out in a simple and beautiful manner. One important series after another, broken and marred by decimal misrepresentation, falls into regular and harmonious sequence, and the

geometrical relations, which to the worker in any branch of science or art are of essential importance, in a larger measure than is possible under any other radix, are represented in their real significance.

This is in itself no slight advantage, for geometry is of all sciences the most tangible and practical. How comes it to pass that the dozen holds its ground so persistently in commerce, notwithstanding the convention of reckoning by tens? Very much because there are so many ways of making a convenient and compact parcel of twelve equal units, while tens and hundreds pack very badly indeed, making misshapen parcels and wasting space. To those who have to pay freight charges—as all must do, directly or indirectly—this is a consideration of importance.

The two ratios with which the practical work of life brings us into constant contact are graphically represented respectively on the clock-dial and the compass-card. With both of these decimals are in constant discord. The old Babylonian division of the circle into 360 degrees is comprehensive enough to take in the decimal, but its place is subordinated to the more important and significant geometrical angles, which only duodecimal division can give.

It may be regretted that a numerical system so nearly perfect as the duodecimal—simplifying as t would all the practical mathematical work of the world to an amazing extent—can never, unless humanity develops an unforeseen capacity for the acceptance of great reforms, be adopted. If it were merely a matter of relative merit there could be no doubt of the result, for mathematicians are unanimous as to its superiority. But one of the great arguments against the metric system applies with equal force to duodecimalism. The decimal radix is so strongly entrenched in tradition, in notation, in thought, speech, and literature, that its dislodgment may be reasonably assumed to be impossible. We find a tacit recognition of the place that twelve should occupy of right in the significant facts that our popular multiplication-table extends to 12×12, and that children are taught simple multiplication and division up to twelve, not ten. And hampered though we are in all directions by our defective arithmetical radix, we still are free to use, in weighing and measuring, the divisions that the experience of many ages has proved to be the best adapted to our needs. That freedom it is the avowed object of the metrists to destroy. They would widen still further the gulf that unfortunately divides arithmetic from geometry, and make our bondage to the decimal complete.

In any notation two radices are required—a major as well as a minor—and it is important that there should be

due correlation between the two. There is a notable difference in this respect between the ancient system, universal in the British Empire, and the modern French scale. While our own system does not appear to be the best possible, this correlation is duly observed; in the French scheme it is neglected, with the result that the nomenclature is unscientific and misleading. It is the usual convention to break any long series of figures into groups of three for the sole purpose of facilitating reading. The comma, usually employed for this purpose, is no more a mark of grammatical punctuation than the period when used as a decimal point. But French numeration is so glaringly anti-arithmetical that it can be explained only on the theory that in their inveterate habit of mistaking arbitrary symbols for scientific facts the devisers of the scheme attached some occult mathematic significance to the triple grouping. In fixing the major radix the question arises at which stage to abandon ten and substitute a multiple. Theoretically, as it is easy to show, the second radix should be a power of ten which is (1) a square number, and (2) the roots of which are also squares till we reach the square of ten. Such numbers are successively one hundred, ten thousand, and one hundred millions. Either of these, radically subdivided, brings us in the end to ten; any other multiple of ten will yield as its root number an interminable decimal. For the larger radix one hundred is obviously too small; multiplied by a million it is inconveniently large. The point naturally indicated for the break, therefore, is the myriad, in which case the ciphers would properly be grouped not in triplets but in fours. By this arrangement the numeration table would stand thus, the square numbers being indicated by small capitals :—

ONE	1
First Series (Minor Radix).	
Ten	10
HUNDRED (10^2)	100
Thousand (10^3)	1000
MYRIAD ($10^4 = 100^2$)	1,0000
Second Series (Major Radix).	
Decamyriad (10^5)...	10,0000
MILLION ($10^6 = 1000^2$)	100,0000
Milliard (10^7)	1000,0000
BILLION ($10^8 = 100^4 = 1,0000^2$) ...	1,0000,0000
TRILLION ($1,0000^3 = 100,0000^2$) ...	1,0000,0000,0000
QUADRILLION ($1,0000^4 = 1,0000,0000^2$)	1,0000,0000,0000,0000

In this scheme the first and second series are consistent and complementary; the powers of the minor radix are in-

dicated by the number of ciphers and those of the major radix by the number of groups, the index-prefixes "bi," "tri," &c., agreeing with the power. By this plan, and this alone, the comma dividing the groups becomes a significant arithmetical sign as well as an aid to legibility. Both the British system and the French are defective in starting from the million, which, though itself a square number, has not a square for its radix. In the British scheme, however, the terms "billion," "trillion," &c., representing as they do the successive powers of the greater radix, are correctly used; but the French nomenclature, in which a thousand millions is called a "billion" and a thousand "billions" a "trillion," is worse than meaningless—it is misleading. If we seek the root of the British billion, the cube-root of the trillion, and so on, we shall always come back to the starting-point — the million, or 10^6. Applying the same process to the French table, we have a series of anomalous results—the root of the "billion" is 31622777 with an endless decimal fraction; the cube-root of the "trillion" is 10,000. The fact that the French have their own specific word, "milliard," for their modern "billion" seems to indicate that the numeration scheme has undergone alteration; and, in fact, I find it explicitly stated by one authority that in France the "older writers" use the same system as our own. I have been unable to ascertain whether the change was made as recently as the revolution at the close of the eighteenth century, so few writers concern themselves with the historic aspects of the question; but I am inclined to think it belongs to a remoter period. Unfortunately for the English-speaking world, the French method has become prevalent in the United States, causing such confusion in the interchange of newspaper items and literature in general that one meeting with a reference to a "billion" in print, unless assisted by the context, can never be sure whether a thousand millions or a million millions is intended. Stranger still, the French notation was most unwarrantably introduced into at least one important English text-book—the Sandhurst Military College Arithmetic —but appeared, I am informed, in one edition only. Its temporary adoption in this academy, however, has led to serious confusion. When the present Education Act came into force the Department found both systems being taught to the children of New Zealand, certain provincial Inspectors apparently preferring the French method, and it became necessary to issue a special direction insisting on the uniform use of the British notation in all the public schools. Apart from scientific defects, a low base of computation, especially when combined with a low unit of currency, is not in keeping with the dignity of a great people. Mark Twain

has humorously described the dismay of a small dinner-party at the Azores when the landlord presented his bill, amounting to "21,700 reis," which amount was found after much inquiry to equal 21 dollars 70 cents. But the small billion, in conjunction with a dollar unit, is a boon to "yellow" journalists and others addicted to "tall talk." The "billions" so glibly paraded, even if genuine, which is not always the case, represent about two hundred millions sterling in British currency, and it requires five times as much wealth to constitute a millionaire in Britain as it does in the United States.

Not the least instructive chapter in the history of the French reformers is the record of their failures—failures which shattered the boasted unity of their system even at the outset, and which the metrists of to-day keep judiciously in the background. But it is not quite forgotten that the scheme of these same "reformers" included the consummation of the Christian era, and the institution of the new order in which mankind should recognise one object of adoration only—the Goddess of Reason. In October, 1793, the new calendar, designed for all time, was promulgated. Books dated in the year 1 are still extant. The week was abolished and the decade substituted. The whole scheme of time was decimalised, but the solar system persisted in pursuing its incommensurable movements as before. Doubtless it was this perverse conservatism on the part of bodies celestial and terrestrial that caused a certain astronomer to wish that he had been present at the creation to give the Almighty the benefit of his counsel. The new era was inaugurated with much ceremony and indecorum—for was it not to abide for ever? All books of chronology record the date of its institution, but few give the date of its disappearance. In a very few years it had vanished like a wreath of mist—imperceptibly but effectually.

The geometric circle, like the arc of the meridian, was regraded into 400 instead of 360 degrees. As under the reformed arrangement many of the most important angles could no longer be expressed in degrees, this was one of the first points in which the scheme broke down. In any case, the preliminary quartering of the circle was in itself a silent but none the less eloquent admission of the essential inadequacy of decimalism. In fact, examination of the pretentious scheme, no matter at what point that examination begins, reveals fallacy piled upon fallacy.

Even if our own ancient system had no particular scientific value—if it were really as defective as its assailants assert—we might well hesitate to exchange it for a substitute so ill-considered and so imperfect, quite apart from the incalculable loss and inconvenience such a change would impose upon

us. "History," as a writer of a past generation has well said, "shows that, while Governments change with great facility their money systems, their constitution, and even their religion, weights and measures seem immovable. They are, indeed, so mixed and, as it were, matted with every concern of property that they cannot be essentially altered without violence and confusion. Nor are these evils of a temporary nature. The habits, customs, and prejudices of the multitude are not to be speedily changed." The experience of every country where such a change has been decreed sufficiently confirms the statement. But it is not in the interests of "the multitude" that the change is made, nor are their "habits, customs, and prejudices," if such happen to conflict with the prevailing fashion in science (so called), deemed worthy of consideration. Happily, fashions in science, as in costume, have a way of becoming unfashionable, while despised "habits, customs, and prejudices"—often the intuitive wisdom of the many, or embodying the concrete results of the experience of a distant past—have a perennial vitality extremely irritating to the exponents of the latest theories.

After all, our national measures, which—in these days of rampant "Imperialism," too!—it has become the unpatriotic fashion to contemn, are fundamentally more scientific, as well as more generally convenient, than their foreign rivals. They are no mere "accidental" inheritance, nor do they show any signs of haphazard origin. Whence the Saxons derived them, and how, is not known; but they can be shown to possess a venerable antiquity, and to have passed down the ages practically unchanged. A jealous regard for accurate standards is an ancient characteristic of our race. Were there such a thing in nature as an immutable standard, convenient and everywhere accessible, no doubt it would have been accepted, but no such natural unit has ever been found. The wise men of old everywhere selected the nearest approach which has yet been found to such a unit. They did not take a random terrestrial measurement with neither scientific nor practical value. They recognised that measures were subordinate to man and not man to measures, and from first to last, therefore, their standard was "the measure of a man." Proof of this fact is built into the very structure of language. There is not an ancient term of measurement in our tongue, save those denoting infinitesimals, that cannot be referred to the human frame.*

* The fathom is the height of a well-developed man, and also the stretch of his arms, which, in fact, the word itself signifies. Philologists refer it to the root "fat," to extend. The Saxon word "fæðm" signifies "the space reached by the extended arms—reach, embrace." In Danish,

Can creation furnish a better unit? I do not think so. All men are not six feet high, nor are their feet usually twelve inches in length, and it is obviously true that any one who should in his own person combine all the precise measurements which derive their names from the human frame would not be a model for an artist. The necessity that each measure should bear an aliquot relation to all the others—the variations in human stature and build—make exact correspondence with any of them the exception rather than the rule. They are, as it were, the rough draft, from which, by comparisons and averages, the actual standards of reference have been derived. They are, however, near enough for most of the practical needs of daily life; they are universally accessible as no external standard can possibly be; and the man who takes the trouble to ascertain and make due allowance for his own "personal equation" may still serve as his own standard, and be to a great extent independent of external aid. I have seen a tall Maori measuring off a fabric by the "faddom," using his arms as a gauge, and he did not give himself short measure, as a tape afterwards proved. I have seen women measure off yards with great correctness by hand and eye alone; and the accuracy with which distances can be "paced" does not need to be pointed out. The so-called "patriotic" exercises in our schools, instead of taking the questionable form of homage to a flag, would be better devoted to explaining the beauty and value of our far more ancient standards. If the children were exercised in weighing and measuring by the eye and hand, their work being afterwards tested—in drawing and subdividing six- or twelve-inch scales from memory—they might in after-life be to a great extent independent of artificial standards, except where commercial or scientific accuracy was required.

The antiquity of our measures may be inferred from the fact—which is abundantly demonstrated—that they are built into the Great Pyramid of Egypt, the oldest of all the pyramids, the others being very indifferent imitations—sepulchral

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an allied language, the expression for "to embrace" is *at tage i favn*, literally "to take in fathom," the two nouns being identical. The cubit, yard, and ell refer to arm-measurements; the span, the hand, the foot need no interpretation. "Inch" and "thumb" are convertible terms in more than one living language, and the old "finger-breadth" was two-thirds of an inch. The "pace" is the unit of the longer measures; "mile," a numerical term, literally means a thousand paces. Measures were also calculated by days' or hours' journeys and variously subdivided. Naturally among different peoples these have diverged more widely than the smaller measures; hence we have the modern mile varying from 11,700 yards in Sweden to 1,165 yards in Russia. But from the finger-breadth to the league the man himself is always the ultimate standard.

monuments embodying no mathematical science.* In the Pyramid we find most unmistakably the inch and the cubit of 25 inches; all the measures of weight and capacity are based upon the inch, and the central chamber where they are deposited is perhaps the most perfect contrivance for securing uniformity of temperature ever devised by the skill of man. In the Pyramid standard measure of capacity, equalling four British "quarters," we find the origin of the term, the larger measure having been so long disused that the fractional name has been somewhat of a puzzle.† A further example of the little change which a traditional standard may sustain when carefully preserved is found in the fact that our inch differs from its prototype in the Pyramid by only the thousandth part (*minus*).

If the basis of our measure be the noblest of all—man himself, so its popular divisions are in practice more adapted to his daily needs than the new ones. Only last year a photographic journal complained that the French system provided no convenient-sized storage-bottles, and said that photographers who, perforce, did laboratory work on the metric

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* So many strange and fanciful theories have been associated with this structure—specially built to embody the astronomical and mathematical science of its founders, and to afford an enduring record of their standard of weights and measures—that it is almost necessary in referring to the subject to disclaim the religious theories which—unfortunately, I think—have been associated with it. Such, for example, as that its builders were divinely inspired, and that it is "a prophecy in stone." To the late Professor Piazzi Smyth, Astronomer Royal of Scotland, belongs the credit of making the first exact measurements and of interpreting the mathematical and astronomical significance of the venerable monument; but I cannot but think the usefulness of his work was marred, though its accuracy was not affected, by his theological bias. He disliked the division of the circle into 360 degrees not on scientific grounds, but because that method was used by the idolatrous Babylonians. He accepted as fact the Rabbinical tradition recorded by Josephus, that Cain added to his iniquities by devising weights and measures that he might defraud those with whom he had dealings—a story in much the same category as that in the apocryphal Book of Enoch, whence we learn that an evil demon, Penemue by name, taught the children of men writing and the use of ink and paper, with every secret of wisdom, whereby many have gone astray from every period of the world, and by their knowledge they perish.

† A remarkable feature of the Pyramid standard is that it deals only with the concrete, avoiding notation of any kind. It cannot be said to be binary, decimal, or ducdecimal—it is, like number itself, independent of them all, and its interpreter must find and apply his own radix. In this respect it is consistent with its plan, for it is unique among Egyptian monuments in that it is absolutely without inscription, bearing neither hieroglyph nor alphabetic symbol. Piazzi Smyth was as thorough a decimalist as he was an opponent of the "atheistic *mètre*," but he could find no decimal or other radix in the structure. In form it is a five-sided crystal, and if it has a key-number (which is doubtful) that number would seem to be 5, for its cubit is 5×5 inches.

system kept Winchester quart bottles for storage, and in preparing solutions thought and worked in the old standards. Yet another worker in the same field, criticizing the nomenclature, said it was, according to all the laws of thought, a defect. A separate characteristic name for each successive unit gives it individuality, whereas the cumbrous and indistinctive names in the metric system are found in practice to be a source of error.

As we have seen, the French scientists went to great pains and expense to have some kind of cosmic basis for their system. Our own system has not only the microcosmic basis supplied by man himself, but according to the late Sir John Herschel (who, by the way, did not take the Pyramid into account at all) has relations to earth and water more striking and harmonious than any the rival system can boast. Sir John could speak on this subject, if any man could, with authority. He was the ablest and most learned member of the Standards Commission, and his letter to the *Times*, written more than thirty years ago, is so much to the point that I quote it in full:—

As Mr. Ewart's Bill for the compulsory abolition of our whole system of British weights and measures, and the introduction in its place of the French metrical system, comes on for its second reading on the 13th proximo, I cannot help thinking that a brief statement of the comparative *de facto* claims of our British units and of the French on abstract scientific grounds may, by its insertion in your pages, tend to disabuse the minds of such, if any, of our legislators who may be under the impression (I believe, a very common one among all classes) that our system is devoid of a natural or rational basis, and as such can advance no *à priori* claim to maintain its ground.

De facto, then, though not *de jure* (*i.e.*, by no legal definition existing in an Act of Parliament, but yet practically verified in our parliamentary standards of length, weight, and capacity as they now exist), our British units refer themselves as well and as naturally to the length of the earth's polar axis as do the French actually existing standards to that of a quadrant of the meridian passing through Paris, and even in itself better, while the former basis is in itself a preferable one.

To show this I shall assume as our British unit of length the Imperial foot, of weight the Imperial ounce, and of capacity the Imperial half-pint, and shall proceed to state how they stand related to certain prototypes, which I shall call the geometrical ounce, foot, and half-pint; and shall then institute a similar comparison between the French legally authenticated *mètre*, *gramme*, and *litre* in common use with their (equally ideal, because nowhere really existing) prototypes, supposed to be derived from the Paris meridian quadrant, distinguishing the former as the practical, the latter as the theoretical, French units.

Conceive the length of the earth's axis as divided into five hundred million equal parts or geometrical inches. Then we will define:—

(1.) A geometrical foot as twelve such geometrical inches;

(2.) A geometrical half-pint as the exact hundredth part of a geometrical cubic foot; and

(3.) A geometrical ounce as the weight of one exact thousandth part of a geometrical cubic foot of distilled water, the weighing being performed, as our Imperial system prescribes, in air of 62° Fahr. under a barometric pressure of 30 inches.

In like manner the theoretical *kilogramme* and *litre* of the French are decimally referred to their theoretical *mètre* on their own peculiar conventions as to the mode of weighing.

This premised—(1) The Imperial foot is to the geometrical in the exact proportion of 999 to 1,000, a relation numerically so exact that it may fairly be considered as mathematical; and (2) and (3) the Imperial half-pint and ounce are, each of them, to its geometrical prototype as 2,600 to 2,601.

Turn we now to the practical deviations from their theoretical ideals in the case of the French units. Here again (1) the practical *mètre* is shorter than its theoretical ideal. The approximation is, indeed, closer, but the point of real importance is the extreme numerical simplicity of the relation in our case, more easily borne in mind and more readily calculated on in any proposed case. (2 and 3) Any error in the practical value of the *mètre* entails a triple amount of aliquot error on the practical *kilogramme* and *litre*, so that in the cases of these units the proportion between their practical and theoretical values is not that of 6,400 to 6,401, but of 2,133 to 2,134. Here, then, the greater degree of approximation is in our favour; and it is to be observed that in our case this triplication of error does not hold good, since by a happy accident our standard pound has been fixed quite independently of our standard yard, and our gallon is defined as 10 pounds of water.

Like all other terrestrial things, the earth's axis is doubtless subject to minute secular changes; but it is at least a right line, and a line of unique significance, as it is used by astronomers as the unit-measure for distances within the solar system. It is therefore very convenient that it should harmonize with our ordinary standards. Moreover, its length —five hundred million inches—is a consistent decimal relation, which the forty million *mètres* of the French system is not. Was it, however, by a mere "happy accident" that such remarkable concordances occurred? I have more faith in both the knowledge and wisdom of the men who devised them of old than to think so. Astronomically and mathematically, the self-complacent French scientists of a hundred years ago were as babes compared with the architect of the Pyramid.

Sir John Herschel's casual reference to the "peculiar conventions" of the French method brings out another instance of the practical nature of our system as contrasted with the artificial and *doctrinaire* methods of the metric system. British observations and tests are made under reasonable and normal conditions of atmospheric pressure and temperature. The French observations have to be corrected to the practically impossible conditions of sea-level and the freezing-point of water.

The British people are free to use, and do habitually use, decimal divisions of their own standards wherever such division is found to be right and convenient. Any instrument-dealer will supply rules graded into eighths, tenths, or twelfths, as desired. Foreigners are not so ignorant of our standards as the metric advocates would have us believe.

For British buyers they are quite willing to manufacture to British measures. Beautiful and accurate scales to English feet and inches are "made in Germany." Time has been decimalised for the navigator's convenience, as the Nautical Almanac tables show; but it would be an intolerable inconvenience to have to exchange our present clocks for ten-hour dials.

That our foreign trade would benefit by the change is more than doubtful. While we were painfully and laboriously discarding all our patterns and making new tools—probably we should find it necessary to purchase most of them abroad—our foreign rivals, with all their scales ready to hand, would have an unprecedented opportunity of invading all our markets, and during the time of transition, at all events, would have an overwhelming advantage. Just as free trade and exchange throughout the United States has brought vast prosperity, so, high authorities maintain, British success in trade has been in great measure due to the uniform system of standards existing throughout the British-speaking world. Is this colony desirous to strike the first blow to break it up? France was once kind enough to hint that she would consent to reckon from the Greenwich meridian if Britain would adopt the French measures. Was the suggestion made for Britain's advantage? Scarcely. France would be the gainer in such a compact by both changes.

The question is a vital one. Even if the change could be shown to be for the better, would it be worth the price we should have to pay?

Every individual in the community would be injuriously affected. Every map, from the magnificent British Ordnance Survey to the diagrams on the margins of deeds, would require recalculation on an incommensurable scale. In the case of city frontages particularly, where fractions of inches are precious, the recalculation would be a fruitful source of dissatisfaction and dispute.

All contractors' calculations of quantities, all measurements of bricks, timber, and other building material, would be affected. All graded instruments, from the artisan's two-foot rule to the costly and delicate apparatus of the engineer, would have to be replaced, all patterns superannuated, all calculations translated. If workmen only realised what it meant to them the trades-unions would make inflexible opposition to the change the foremost item on their programme. They will protest loudly enough, we may be sure, the day that it is sprung upon them. Then it will be too late. Those concerned are not so supine in the United States. I read, only a few days ago,* that the American Society of Civil

* *Engineer*, 7th August, 1903.

Engineers sent out a ballot-paper with a series of questions on the subject. There were 514 responses, and the adverse votes were three to one.

Our textile goods would be affected. The housewife would no longer buy fabrics by the yard, nor could she do her marketing by the pound.

All familiar landmarks, such as milestones and railway distance-pegs, would be obsolete. No doubt the State, to set an example, would at once set about pulling them up and grading in kilometers. "A frightful waste," says a correspondent of the *Engineering World* (London), "and for what use?"

To the astronomer it closes the ledger which, as Proctor told us, has been kept posted for three thousand years. The navigator's tables and books of reference will be obsolete, and the shipowner will have to forget his tonnages. The occupier of land—owner or tenant—must recalculate boundaries and recompute superficial areas. The Land and Survey Department would have the same costly task, and on a truly magnificent scale. Two-thirds of the world's trade would be disorganized while the change—necessarily slow—was in progress.

It would play cruel havoc with our national inheritance of literature. The nomenclature is barbarous and unconformable to the genius of our tongue, while our classics, if the present standards ever became obsolete, would require continual annotation. Let us open an edition of Shakespeare, say, of A.D. 2003:—

> A merry heart goes all the day,
> Your sad tires in a mile-a.*

> This bond is forfeit,
> And lawfully by this the Jew may claim
> A pound [= 0·454 kilo.] of flesh.

> Full 9·144 meters thy father lies;
> Of his bones are coral made.

How the substituted nomenclature could be worked into English verse (other than burlesque) is a question that poets would have to settle.

On patriotic and commercial grounds alike we should resist the change. The widest charity does not require us to commit commercial suicide that France and Germany may enjoy increased prosperity.

I have already referred to the impossibility of restoring the metric standard by repeating the original measurements; also to the fact that after the lapse of a century the old standards are not extinct in France. Will it be credited that a German advocate of the meter urges the necessity for careful preserva-

* Mile.—An ancient lineal measure 1·609 kilometers.

tion of the neglected ancient standard in order that it may remain as an authoritative check by which the accuracy of the meter may be tested? It reads like comic opera, but it is true. In the "History and Review of the Toise Measure Standard," published by Ferdinand Dummler, Berlin, Professor Dr. W. Foerster, who writes the introduction, says,—

> The old French system, whose unit was the toise graduated in six Parisian feet (= 72 Paris inches = 864 Paris lines) is also at present, next to the universal and exclusively recognised (legal) metrical system, of great scientific and practical value, since the same has not only been the starting-point for the fixing of the basis of the metrical system, but even at the present time has found employment in pendulum observations, and, by reason of its inclusion in numerous good measure scales and basis-measure apparatus, in land-surveying, especially in Germany. In order to secure a fixed and accurate transition from all the old French units of measurement to measurements according to metric units, and thereby to take the last step to overcome the old system, and finally to attain a homogeneous basis for all measurements, it is of great importance that there should be made as soon as possible in the International Weights and Measures Office a new comparison between the unit-lengths of the old French system and of the metric system.

The whole passage, though not so intended, is a powerful indictment of the pseudo-science which wantonly cast aside an established and useful standard for a newly devised and nondescript substitute. Professor Foerster, it may be observed in passing, does not speak disparagingly or contemptuously of the old inch-and-foot scale; but, on the contrary, acknowledges its "great scientific and practical value"—as British folk will begin to do after they have lost it, if the metrists have their way. It may be as well to explain, however, how this dependence of the accuracy of the metric standard on the ancient Paris standards arose. Of course, the arc of the meridian could not be measured in "*mètres*," because that measurement was a preliminary to its establishment; and the surveyors necessarily made use of the authoritative scale which it was their purpose to supersede. The meter is usually described as equal to 36·9413 French or 39·3708 English inches. Its precise length, however, was reduced to French lines, of which it equals 443·296, and to this standard it would require to be referred should any question hereafter arise. Evidently there is considerable vitality in the old inch-and-foot scale still, even where it has been most rigorously suppressed; and in the coming Battle of the Standards for the supremacy of the world it may yet come off victor. By clearing the field of all inch-and-foot systems save the British it has greatly simplified the issue. What the result of the conflict will be it would be idle to predict; but there can be no question that the fittest will survive if the English-speaking world, awakening to the importance of its trust, remains united, and "England to herself be true."

II. — ZOOLOGY.

ART. VIII.—*The Kohoperoa or Koekoea, Long-tailed Cuckoo* (Urodynamis taitensis): *An Account of its Habits, Description of a Nest containing its (supposed) Egg, and a Suggestion as to how the Parasitic Habit in Birds has become established.*

By ROBERT FULTON, M.B., C.M., Edin.

[*Laid on the Table at the Annual General Meeting of the Otago Institute, November, 1903.*]

So little is known of the breeding-habits of the Long-tailed Cuckoo that the description of a nest containing what I believe to be the egg of this interesting bird may be considered of some ornithological importance.

The Long-tailed Cuckoo is a native of the South Sea Islands, and visits us annually in the spring, breeding with us, but the task of feeding its young is very frequently carried out by the Grey Warbler (*Gerygone flaviventris*), a species which actually hatches and brings up the young of the Bronze or Shining Cuckoo (*Chalcococcyx lucidus*), another summer visitant(1). How the egg of the Shining Cuckoo is placed in the nest of the Warbler is as yet unknown; the Cuckoo probably lays the egg on the ground and then places it in the nest with its beak, for it can hardly get inside the nest without seriously damaging it; and when we come to consider the size of the Long-tailed Cuckoo the difficulty is immeasurably increased. Sir Walter Buller says of this point, "It is difficult to conceive how a bird of the size and form of the Long-tailed Cuckoo could deposit its egg in the domed nest of *Gerygone flaviventris;* and, even supposing that it did, it would seem almost a physical impossibility for so small a creature to hatch it; and, again, were this feasible, it is difficult to imagine how the frail tenement of a suspension nest could support the daily increasing weight of the young cuckoo"(2). This objection has been raised by others,(3) and from my own observations of the nests of *Gerygone*, and the fact that the barely fledged Shining Cuckoo fills the nest to almost bursting-point, I am convinced that the Warbler rarely, if ever, hatches the egg of *Urodynamis*. Sir Walter Buller was long of the opinion that the Cuckoo hatched its own egg and then cast its offspring upon a charitable world

for support. This view was suggested by the fact that he once shot an adult female of this species in which the under-parts were quite denuded of feathers, as though the bird had been long incubating(4). In addition to this the strange fact that birds of many different species had been seen to feed cuckoos(5) gave him the idea that the true parent hatched the egg, and then left the chick to the "bird world in general" for its support and maintenance.

It is reported of the Kermadec Islands that a resident, thoroughly familiar with the birds there, and a reliable observer, has frequently seen the old Cuckoos feeding their young, and considers that they build their own nest, and bring up their young themselves(6). It is not, however, stated whether this nest-building is mere surmise or gathered from actual observation. It is quite possible that an occasional Cuckoo may, under the influence of atavism, actually build a nest and hatch an egg or eggs. An instance is recorded of the Great Spotted Cuckoo of Europe having been said to have built a nest and hatched its young; but all ornithologists of the time discredited the accuracy of the observer, and said that it was a manifest error(7).

In Australia we find Cuckoos, almost without exception, depositing their eggs in the nests of other birds. The Channel-bill (*Scythrops novæ-hollandiæ*) lays her egg in the open nests of the Crow, Sparrow-hawk,(8) Black-backed Magpie, and Pied Crow-Shrike; and the Koel (*Eudynamis cyanocephala*) in the nests of the different Friar-birds and Orioles, all open-nested birds; the Pallid Cuckoo also lays in similar open or cup-shaped nests(9). Nearly all the other Australian Cuckoos, including several large ones, and three of the four Bronze Cuckoos, carefully select dome-shaped or covered-in nests for the home of their young(10). Now, the question arises, How are these eggs placed in their respective nests? Dr. Ramsay asserts that they are laid in the nests, and not deposited in any other manner, for he says that the average width of the entrances of the nests of the *Acanthizæ* which have not been visited by the Cuckoo is 1 in.; while those which have contained Cuckoos' eggs vary from 2 in. to $2\frac{1}{2}$ in.(11). Mr. Archibald Campbell is of the contrary opinion, asking, "How can the Fantail Cuckoo, a bird about 10 in. long, including a tail 5 in., enter the small, covered, dome-shaped nest of a Tit, *Acanthizæ* species, the longest exterior diameter of which is only $4\frac{1}{2}$ in.?" The side entrance that hardly admits of one's finger may be enlarged by the Cuckoo thrusting its head in(12). Dr. Brehm gives us an account of the egg of the European Cuckoo, which was deposited in the nest of the Water-wagtail. The hole leading to the nest was large enough for the passage of the Wagtail,

but not of the parent Cuckoo, and the young Cuckoo, which was hatched out in due time, delayed his departure from the nest until too late, his size being the cause of his permanent imprisonment(12*a*). Mr. Jesse refers to the fact that he has found the egg of the Cuckoo in a nest, where it was impossible for the bird to have deposited it other than by its bill(12*b*). M. Oustalet says, "The Cuckoo watches the moment when the mother quits its nest then, laying its egg, seizes it by its mandibles, passes it into the throat with the agility of a conjuror, and flies to deposit it delicately in the stranger's nest." The fact of the Cuckoo carrying her egg in her bill is now generally admitted. If such be possible with the European Cuckoo, why not with our Australasian species also? Mr. Best, of Branxholme, Victoria, says, "In the season of 1888 I shot a Fantail Cuckoo, and on dissection it proved a specially interesting specimen, as in its ovary I found a nearly perfect egg, and in its gizzard another egg, which, though much broken, was evidently an egg of the same species, probably of the same bird. The season was a late one, and the conclusion I drew was that the bird had carried the egg about for a considerable time, and, being unable to find a suitable nest, had simply swallowed it. In Tasmania a fresh egg of the Fantail Cuckoo was found deposited on a bare stump. Doubtless it had been laid there by the bird, which was probably disturbed before it could convey it away to some suitable nest"(12).

There have been a few fortunate observers who have actually seen the deposition of the egg upon the ground by the Cuckoo, who then, taking it in her bill, introduces it into the nest. The most positive evidence on this point is that of Herr Adolph Muller, a forester at Gladenbach, in Darmstadt, who says that through a telescope he watched a Cuckoo as she laid her egg on a bank and then conveyed the egg in her bill to a Wagtail's nest(13). With one exception, all the Australian Cuckoos are parasitic, and it seems to me reasonable to believe the same of the Long-tailed Cuckoo of our Islands. The occasional supervision by adult Cuckoos of their young ones, and even feeding of them, to which I shall presently refer, has possibly led to the belief that these birds sometimes hatch their own eggs; but there is no evidence that this ever occurs, beyond the curious fact mentioned by Sir Walter Buller as to the female bird he shot. We may therefore assume that the Long-tailed Cuckoo, like its Australian kindred, either lays its egg on the ground and then carries it to a suitable nest, into which it drops it by its bill, or else it finds a nest with a good-sized opening and, settling upon it, lays its egg therein. It no doubt chooses the nest of a bird which is insectivorous, and trusts to Providence, and

the fact that most of the smaller birds will minister to any unfortunate fledgling which by plaintive piping shows signs of hunger. During the months of October and November it is no uncommon sight to see the smaller Australian birds feeding the young of the Cuckoos. Even the little *Acanthizæ*. which are seldom, if ever, the foster-parents of the Pallid Cuckoo, join in supplying the wants, which are made known by the continual peevish cry, which stops only while feeding is going on or when the appetite is fully appeased. So with the New Zealand birds: the Mocker, the Tui, the Warbler, the Tomtit, the Robin, the Brown Creeper, the Canary, the White-eye, and the imported House-sparrow are all known to feed the Cuckoo bantlings, not because they are purely duped, but very often from a true philornithic spirit(19). There is no doubt that at times the parent Cuckoos exercise a sort of general supervision over their young ones, to watch, as it were, in order to see if they are well tended, and at times to actually assist in feeding the youngsters. This is at variance with what we are told by Professor Newton, who says, "The assertion that the Cuckoo herself takes any interest in the egg that she has foisted on her victim, or of its product, there is no evidence worth a moment's attention"(14). To show that there is some evidence that the parent bird does occasionally take interest in the welfare of the product of the egg we need only refer to Miss Bell's report of the Kermadec Cuckoos, and to Mr. Archibald Campbell's book, which mentions several instances: "Channel-bill Cuckoos make their appearance just before or during floods, laying principally in Crow's nests. Later on, or prior to leaving, the old Channel-bills go round and gather up their young, when some hard fighting between the Channel-bills and the Crows usually ensues"(15). The young Koel, or Flinders Cuckoo, was found in the nest of the Friar-bird near Chinchilla, Queensland. Mr. Broadbent watched the young Cuckoo coming out and the old Friar-birds feed it. The adult Koel used to come about the nest at night, remain until dawn, and then fly away till next night(16). Miss Fletcher, writing to the *Australasian*, 30th May, 1896, says, "I myself have seen a full-grown Pallid Cuckoo feeding a young one of the same species. The young one when flushed flew feebly, and I judged it had only recently left the foster-parents' nest"(17). Mr. Campbell asks, "Do Cuckoos sometimes assist the foster-parents in feeding their young, or had these particular youngsters lost their foster-parents?" He further adds, "I am inclined to believe that many birds by instinct feed young Cuckoos, whether they be the rightful foster-parents or not. Only last season Master Bardwell watched a young Cuckoo, either a Pallid or a Fantail, being fed,

first by a Scarlet Robin (*Petroica leggii*) and then immediately after by a Spine-billed Honey-eater." With reference to the statement that young Cuckoos are sometimes fed by old Cuckoos, Dr. Ramsay says, "While walking through a half-cleared paddock I was not a little surprised, upon hearing the cries of a young Cuckoo, to see two adult birds of the same species (*Cuculus pallidus*) flying after it, settling beside it, and apparently paying it great attention. Several times they flew away, but returned to it again, and from their actions I am convinced that they were feeding it, though I was unable to obtain a view sufficiently close to make sure of the fact"(18). Of the Indian Koel (*Eudynamis honorata*) Allan Hume says, "I have never seen Crows feeding fully fledged Koels out of the nest, but I have repeatedly watched adult Koels feeding young ones of their own species. I am pretty nearly convinced that after laying their eggs the females keep somewhere about the locality, and take charge of the young directly they can leave the nest, but I never saw more than one young one in the charge of an old female"(16*a*).

Mr. Ivy gives several instances of South African Cuckoos lurking about nests in which they had deposited their eggs, and undoubtedly keeping an eye on them; and he says that he saw two adult birds, *Coccystes glandarius*, with five young ones, all flying together late in February(110). This may have been a pair which had mated, built a nest, and hatched out a brood; but this bird is considered always parasitic, and Mr. Ivy was of the opinion that the old birds had merely collected their brood previous to migrating. One of the most remarkable facts in this connection is the deposition in other birds' nests of eggs already partly incubated(38). This shows that the egg has been either already sat on by the mother Cuckoo, or removed from one foster-nest to another. This is known to have occurred, Mr. Bendire narrating a most interesting account of it(112). Is it possible that there is still another way in which the egg could be partly incubated—namely, by the heat and moisture of the bird's own mouth and throat while carrying the egg about in the search for a suitable home for it(111)? Nests found one day with fresh eggs in them, and next day with partly incubated eggs of Cuckoos in addition, give one food for reflection(96). Many observers have recorded the feeding of the New Zealand Long-tailed Cuckoo by the Grey Warbler, but I can find no instance of a young one being found in the nest of that bird, and but a single occurrence of a supposed egg. An egg stated to be that of the Kohoperoa was sent to Sir Walter Buller by the Rev. Mr. Taylor, of Wanganui, but he did not say from what nest he had removed it, though it seemed to correspond in appearance

with one taken in 1885 by Mr. W. Smith (of Oamaru, now of Ashburton) from the nest of *Gerygone flaviventris*(20). It was almost spherical in shape, with a slightly rough or granulate surface, of a pale-buff or yellowish-brown colour; length 1·25 in., breadth 1·15 in. A third egg somewhat similar in appearance was found by Mr. Smith in 1888 in the nest of the Wood robin (*Myiomoira albifrons*), and, being allowed to hatch out, proved conclusively to belong to the Long-tailed Cuckoo(20). As this is the only case on record of the discovery of the egg and its subsequent proof of identity by successful incubation I shortly refer to it. He found the Robin's nest with four eggs, and next day the egg of the Cuckoo among the rest. When the eggs hatched the young Cuckoo was of enormous size compared with his mates, and was a very helpless creature, with the skin almost entirely naked and the eyes closed. It throve well, being kept supplied with food by the Robins, and grew rapidly, and was soon too large for the nest, and had to lie on top of the young Robins, which appeared instinctively to crouch at the bottom of the nest for self-preservation, for if the young Cuckoo could have displaced them he could have occupied the whole of the cavity of the nest. Finally Mr. Smith removed two of the young Robins in order to make room for the increasing size of the Cuckoo. The remaining Robin did well, being soon nearly ready to fly. Unfortunately, Mr. Smith did not describe the egg further than to say that "it was almost round in shape, and of a deeper shade of colour than the specimen in the Canterbury Museum." In Buller's book there also appears from the pen of Mr. Smith a graphic account of the hatching of the egg of the Bronze Cuckoo by *Gerygone flaviventris*, and it seems from this that the young intruder was practically fledged and ready to fly in about ten days, and in a fortnight voluntarily quitted its home, which it is, however, right to mention had been placed on the ground. It had accomplished this remarkable development by appropriating all food which came to the nest, and had doomed its unfortunate companions to a cruel death by starvation(21). No doubt the Shining Cuckoo chooses the domed nest of the Warbler because this is large enough for the young bird until it is nearly fledged and ready to fly, and the young bird can escape from the nest without fear of injury by falling. The Long-tailed Cuckoo, on the other hand, would seldom select this nest for its young, as the bird, owing to its size, would have to leave long before it could fly, and might easily be seriously injured, at that tender age, by falling from the height at which these nests are built. For this reason the parent Cuckoo has, through myriads of generations, probably come to deposit her egg in an open nest close to the

ground; or one, at any rate, in which the young can attain to a fairly good size before leaving, and can thus reach *terra firma* without much fear of injury. In Mr. Smith's case the young *Urodynamis* at a fortnight quite filled the nest, and at three weeks was well plumaged, but only able to move about weakly on its legs; it does not seem to have made any attempt to fly, but was still a huge helpless creature. This bears out what I before said as to the unsuitability of the nest of the Warbler as a habitation for this Cuckoo; and the fact that no one has ever found the young bird in such a nest makes it probable that the deposition of the egg of the Long-tailed Cuckoo in the nest of the Grey Warbler is of very rare occurrence. The picture in Buller's book showing the feeding of the young Cuckoo by the Warbler is, however, an accurate representation of what often takes place; the helpless youngster crawls from the nest to the ground or large tree-trunk, and on the ground or trunk do the various kind-hearted little insectivores feed it. I wish some of our Australian ornithologists would refer to the young of the Fantail Cuckoo, and give us details of their upbringing in the tiny little nests of the *Acanthizæ*. Do many of these birds perish for the reasons I have mentioned? How soon do they leave the nests? and have many instances occurred of the actual discovery of the young Cuckoo in one of these nests? The eggs are deposited therein, but are they hatched, and, if so, what is the ultimate result? Does the Cuckoo throw out its mates? How does it get out of the nest, and when? How long can the nest support its weight? In searching for the egg and young of *Urodynamis taitensis* I have paid special attention to the nests of three birds—the Native Canary (*Orthonyx ochrocephala*), the Robin (*Myiomoira albifrons*), and the Tomtit (*Myiomoira macrocephala*). Sir Walter Buller says that a Maori at Wellington told him that the Blue Crow (*Glaucopis cinerea*) lays a single egg, and after hatching it leaves the care of the chick to the Popokatea, or Canary (*Orthonyx albicilla*)(21). Sir Walter could not accept so strange a fact in natural history, and later contributions by the same writer(22) and others quite dispose of the idea that the Blue Crow is ever parasitic(23). It occurred to me that the Maori had very probably mistaken the young unfledged Kohoperoa for the young of the Blue Crow, and that it was the former bird that the Canary had been seen feeding. All nests of the South Island Canary (*Orthonyx ochrocephala*), however, which I have personally examined have shown the natural occupants, and no sign of an intruder; but my surmise proves to be the correct one, for Mr. Elsdon Best sends me the following interesting information concerning the Cuckoo from the Tuhoe natives: "The Koekoea does not build a nest, but takes

possession of and lays its eggs in the nest of the Tataeto bird, sometimes called Tataeko, or Tataihore, the same as the Popokatea, or White-head. I have not seen the eggs of the Koekoea, but I have seen the young Koekoea sitting together with the young of the Tataeto on a branch just after they could leave the nest, and being all fed alike by the Tataeto, which would bring food, feed one after the other, and then fly away to procure more food"(23*a*). Mr Robert Riddle, of Orepuki, found the young *Urodynamis* in the nest of the Yellow-headed Canary, and says that the young Canaries were all ejected by the intruder(100).

The following is an account of a young Cuckoo which had probably just left the nest of the Canary, narrated by Mr. McLean, of Te Tua: "My boy saw a Cuckoo dart several times among a flock of Native Canary, but could not see if any damage was done. The birds did not seem very much afraid of the Cuckoo, but when he came among them they would scatter, and then when he flew to another tree would follow him, and when he uttered his call they also would start chirping: then a larger Cuckoo came and joined it, and they both flew away a short distance." Mr. Westenra, of Akaroa, found a nearly fledged Koekoea in the nest of the Tomtit (*Myiomoira macrocephala*)(23*b*).

Mr. Buckland informs me that the young Koekoea has been seen calling for food, which was being brought regularly to it by a Tomtit(23*b*), and Mr. Potts records a case where the duty of rearing the young of the Shining Cuckoo was intrusted to the same bird, *Myiomoira macrocephala*(23*c*), and Captain Mair says that he has seen the Bell-bird (*Anthornis melanura*) acting in the same kind capacity(24). It is probable that the Bell-bird is called upon to hatch the egg and rear the young of the Kohoperoa, for one may often see the latter bird chased and harried by the Bell-bird, each one giving vent to its rage in a brassy note, like "Peng, peng, peng," frequently repeated, a series of notes or sounds never heard from the Bell-bird or Mocker unless it is in a savage mood. As to the nests of the two species of *Myiomoira*, they are as a rule built on a solid foundation—on a rock, or on the side of a tree, in the hollow of the broad-leaf (*Griselinia lucida*), or in a large fork, and often close to the ground. These are favourable conditions; and another important point is that these nests have fairly large-sized cavities, in which the Cuckoo can easily lay or deposit its egg. I took an egg from a nest in a manuka fork in Richardson's Gully, West Taieri, some years ago. The nest was about 5 ft. from the ground, cup-shaped, and built of moss and ribbonwood-bark, and was extremely like that of the Tomtit (*Myiomoira macrocephala*), but the only egg it contained was of a red

colour, beautifully speckled all over and considerably larger than that of the Tomtit. I have now a strong suspicion that the nest did belong to the Tomtit, and that the egg had been deposited in it by the Kohoperoa. I have for some years corresponded with Ross Bros. who have until lately been working on the Te Anau–Milford Sound route. The Messrs. Ross are keen naturalists, and were always willing to give assistance to tourists interested in the flora or avifauna of their district. I am glad to make mention here that these gentlemen were always determined that no native birds should be killed on or near the track save in case of absolute necessity for food. I trust that the new guides will act similarly. In February of last year I received a letter from Mr. Donald Ross giving an account of a nest and eggs found on the track, and sent to me by same post. It was supposed by those who found it to belong to the Fern-bird, or Utick (*Sphenœacus rufescens*), and the strange egg in it to the Grey Cuckoo(25). Mr. John Ross, who is well known to the scientific world of New Zealand as the fortunate finder of the latest specimen of *Notornis hochstetteri*, wrote as follows: "The nest was found just opposite Mid-camp Hut, in a small fern-bush, not fern-tree. It was underneath the leaves and very hard to find, as you had to lift up the leaves before you could see it. There were four eggs in the nest, three small and one large one, and they were quite fresh. There were several Long-tailed Cuckoos about, and they seemed much annoyed when the boys came on the nest, and kept singing out a good deal all the time they were about it"(26). The nest on examination proves to be that of the Tomtit (*Myiomoira macrocephala*), and contains three Tomtit's eggs and one strange one. It is round in shape, and measures 6 in. in diameter and 3 in. in depth. The cavity is 2 in. in diameter and 1½ in. in depth. It is composed of the ordinary fine bush moss, interwoven with shreds of fine ribbonwood-bark, and ornamented on the outside with pieces of dry white lichen and leaves of the black-birch. It is lined with strips or shreds of ribbonwood-fibre and a minute quantity of wool. The eggs of the nest-builder are ovoido-conical in shape and of a cream-colour uniformly speckled all over with greyish-brown, very similar to the colour and marking of the egg of the Common Lark (*Anthus novæ-zealandiæ*. The three in this nest are slightly smaller than the specimens of the Tomtit's eggs which I have, but the egg of this little bird is very variable. These measure 0·75 in. in length and 0·55 in. in breadth. That which I think is undoubtedly the egg of the Kohoperoa, for I can refer it to no other species, is white with purplish-brown speckles, becoming thicker and darker at the larger end. It is something like that of the

Canary, but is more elliptical in shape—I should call it ovoido-elliptical—and its length is 0·94 in., and its breadth 0·7 in. I have requested the Messrs. Ross, if another egg is found, to allow it to hatch out and in this way positively settle the identity of the egg. I think it likely that many of the eggs are hatched by *Orthonyx* and *Anthornis*, and very soon the young bird crawls from the nest, to be still fed by its foster-parents, *Gerygone* or any other kind-hearted strangers. The egg is quite near enough in appearance to that of the Canary to be easily overlooked in most clutches of eggs of that little bird. It may be objected that this egg differs markedly from the specimens before discovered, but I think you will agree with me presently that that is no reason for our doubting its identity. In the first place, nearly all species of birds at one time or other produce eggs differing markedly from the normal in size and colouring. For instance, I have some specimens of pure-white eggs of *Anthornis* and of *Prosthemadera*; also in my series of eggs of the little Tomtit much variation occurs, but that is not a point I am about to rely on. My opinion is that this is another instance of that wonderful power in nature of producing "protective resemblance." We all know the difficulty in finding the eggs of the Tern among the pebbles of the river-beds; and the eggs of the Dotterel (*Charadrius bicinctus*) are similarly protected. The eggs of the Ground-lark (*Anthus novæ-zealandiæ*) much approach in colour the dusty earth around the depression in which they lie, and it is almost impossible for them to be refound if once lost sight of amidst the dried tussocks and grass around. The same species of Gull lays eggs which differ markedly in ground-colour and blotches according to the part of the beach or to the character of the *débris* and stones among which they lie(26).

The extraordinary difference between the eggs of the two species of *Chalcococcyx*, *lucidus* and *basalis*, has excited much comment, but can, I think, be accounted for in the same way. As we find among the New World Cuckoos several which build their own nests and hatch their own delicate green eggs, let us assume that this is the original natural colour of many of these species. Now, I do not know of very many birds which lay eggs like this, and it may come about, assuming the habit of parasitism to have been first established, that these birds must get their eggs into nests where the wrong colouring will not be noticed, or where the bird is so easily duped as not to object to the peculiar appearance of the strange egg(27). Such dupes do occur, as, for example, the Common Hedge-sparrow will brood with complacency the egg of the Redbreast (*Erythracus rubecula*), so unlike her own that for all we know to the contrary she may be colour-

blind(28). Few birds are so easily imposed upon as this, and these *Chalcococcyx* species, *lucidus* and *plagosus*, have come to find that they are best perpetuated in nests which are dome-shaped or covered in like that of *Gerygone* or those of the Australian Bush-wrens or Tits. The eggs which are deposited in these covered-in nests remain of the original sea-green or olive-green colour, there being no necessity, as the eggs are in comparative darkness, for "protective mimicry" to be established. Now, when we examine the egg of *Chalcococcyx basalis* we find that the egg is white, spotted with pinkish red, quite a different type of egg altogether. Campbell says of this point, "It will be observed that the eggs of the two little Bronze Cuckoos, *plagosus* and *basalis*, are totally dissimilar in colouring, notwithstanding that their respective reputed parents are exactly alike both in colour and size. Both wear coats of glorious green; the young birds are hardly to be separated in appearance, and the adults are extremely alike in plumage, and it would be of great interest if some of our oölogists could explain the apparent anomaly in the coloration of the eggs, for experience teaches us that in nearly every genus the true typical egg of each species is not without characteristic resemblance"(29). Now, the remarkable change in the colouring of this little egg is, I think, easily explained. This bird, as one would expect, lays its eggs more often in open or cup-shaped nests than in closed or domed nests, and the eggs have gradually assumed a speckled colouring very nearly approaching in appearance the egg of our *Gerygone* and many of the smaller Australian birds. In this the Narrow-bill Cuckoo is quite distinct from the other three species of *Chalcococcyx*, whose eggs, being hidden in domed nests, have not required to assimilate themselves to their surroundings. As regards the dark closed nests of the Common English Wren, no adaptation of the egg of the Cuckoo to the eggs of the owner has ever been noticed(87). Many of the European Cuckoos lay eggs which are wonderfully approximate in their colouring to the eggs of those species in whose nests they are deposited; many are abnormally coloured, and quite unlike the ordinary egg of the Cuckoo, but have been proved to belong to that bird on examination of the contained embryos(30). Among the Australian birds the Koel lays an egg which much resembles that of the Friar-bird, one of its foster-parents, and the Channel-bill Cuckoo's egg is very like that of the Hill Crow-Shrike (*Strepera arguta*)(31, 32). Enough has been said to show that much variability may be expected in the eggs of parasitic birds all the world over, and consequently differences in the various specimens of the Kohoperoa need not be considered remark-

able. The egg shown here seems to have assumed an appearance approaching those of the different *Myiomoira* species; it is also very like that of the Canary, and has a faint resemblance to that of the Ground-lark. It is quite within the bounds of possibility that the egg which was found in a Lark's nest by Mr. Reischek, and described by him as a red egg, belonged to the Kohoperoa(33). Unfortunately, he does not say whether the nest was near the edge of the bush, or in a place easily and safely accessible to the Cuckoo. The bird would hardly venture into the open, except for a few seconds at a time, and even then would probably have to return precipitately to its leafy shelter, lest it should be hunted by all and sundry in the neighbourhood. I might here refer to the extraordinary attacks made on Cuckoos by other birds all the world over, and in New Zealand, as elsewhere, they are persistently hunted. Here the Tui and the Mocker are the chief offenders, chasing and tormenting them in the same way as they harry and hunt our Owl *Sceloglaux albifacies* and its smaller congener *Spiloglaux novæ-zealandiæ*. The Cuckoo is semi-nocturnal, and seldom seen, though often heard, by its persecutors; they know it for a stranger, and object to its habits, which drive it to prowl round looking for a convenient lodging for its egg. Besides this, its harsh cry, quietness of flight, its peculiar colouring, hawk-like beak, and cruel yellow iris are all combined to make birds which are otherwise sociable very savage at its approach. It is interesting to note that the Piopio, or Native Thrush (*Turnagra crassirostris*), and the Long-tailed Cuckoo, birds of widely divergent genera, are somewhat similarly plumaged, cruel-beaked, yellow-irised, and hawk-like in appearance. I have never read or heard of the Thrush being chased by other birds, but I have always been struck with its savage appearance. In confinement it is carnivorous, and has been known to devour the eggs of the Ringdove as soon as they were laid, and to actually kill two adult Parrakeets and partially devour one of them(34). It certainly seems to merit the attention of the Tui or Mocker quite as much as if not more than the Cuckoo. The latter bird is said to devour the eggs and young of other birds, and, curious irony of fate, the only instance I can find recorded of this shows the victim to be the very bird I have just referred to, the Thrush, a true case of the "the biter bit." Buller says, "From the stomach of one of them I took the body of a young bird, apparently a Native Thrush, or Piopio, partly fledged and only slightly mutilated, showing the enormous capacity of the Cuckoo's throat"(35). Buller, Potts(36), and Handly(37) all affirm that our Cuckoo is predatory, but I have vainly endeavoured to find recorded any other evidence

of this. Even in Australia one comes across numberless instances of eggs of the various Cuckoos being placed among clutches of eggs of other birds, but not one is recorded in Campbell's book of the Cuckoo having thrown out or devoured the egg of the nest-builder or of any other bird. On the other hand, many instances are reported of the builder having thrown out the egg of the parasite, or covered it up with feathers, before laying its own eggs. This generally happens when the Cuckoo is foolish enough to deposit its egg in the nest before it is fully completed, or before the eggs of the rightful tenants are laid. Many cases are recorded of the destruction or desertion of the Cuckoo's egg by the nest-builder, but few or none of the Cuckoo throwing out or eating the eggs of other birds (38).

Bendire says of the American Yellow-billed Cuckoo, "I am aware that this species has been accused of destroying the eggs, and even of eating the young, of smaller birds, but I am strongly inclined to believe that this accusation is unjust, and requires more substantial confirmation. I have never had any reason to suspect their robbing small birds' nests, and I am upheld in this position by a number of careful observers whom I have questioned on this important subject." Of all the American Cuckoos mentioned by Bendire two instances only are mentioned of this unpleasant habit. The Road-runner (*Geococcyx*), of South California, was stated by Mr. Anthony to have devoured a nest of young Finches, and the Mangrove Cuckoo, of Florida and Key West, was said by Audubon "to be fond of sucking the eggs of other kinds of birds in the absence of their owners." No specific instance is given of any of the Cuckoos being caught nest-robbing, and here, as in other countries, the accusation is manifestly unfair(38*a*). Among the parasitic Cowbirds the curious habit obtains of puncturing the eggs of the nest-builder, but seldom of throwing them out of the nest. This is done purposely by the Cowbird with beak or claws, probably to prevent the eggs from hatching. The parasite has evidently learned that it is as well to refrain from openly interfering with the eggs of the host, but that by making minute punctures in them it will insure their destruction, as the owner, on finding an egg will not hatch, will undoubtedly throw it out herself. Bendire says this puncturing is so often seen that he is certain it is done intentionally, but whether by beak or claws is not known. It is undoubted that eggs of the builder are found beneath the nest at times, but there is sufficient reason to think that this is due to the disappointed parent discarding the addled eggs. This habit of puncturing may have arisen from mere accidental contact in the first place, and this, by enabling the young Cow-

birds in those nests to have less competition for food, would be transmitted as an advantage, while the young Cowbirds which had large families to compete against would have less chance of obtaining sustenance, and would ultimately become extinct(38*b*). Although writers on the American, Australian, and Indian Cuckoos do not report a thieving character thereof, Buller, Potts, and nearly all the writers on the New Zealand bird make the general statement that it devours the eggs of other birds; but no specific instance is given. Mr. Potts gives it as his opinion that many of the eggs of the Blue Crow (*Glaucopis cinerea*) are destroyed by the Cuckoo, but he brings forward no proof of this(39). Personally, I think that if this theory of universal egg-robbing were true it would soon bring about the robbers' extinction, by the nests of all birds which contained an egg of the marauder being deserted, or the egg promptly thrown out by the builder. The "protective resemblance" to a Hawk is, to my mind, acquired partly for the bird's own protection, as it seems to be a poor fighter, but also for the purpose of frightening small birds away from their nests, so that it can quickly seize the opportunity of safely depositing its egg in a comfortable home. The sudden appearance of a large savage-looking bird would make any little Tomtit fly from its nest, and the marauder in this way could utilise her resemblance for the perpetuation of her species.

Professor Newton says, "So far as I can find there is nothing to show that any instance has been known of the Cuckoo stealing an egg, and the whole theory of egg-robbing seems to have arisen from the numberless instances of Cuckoos having been found with eggs in their mouths, throats, or stomachs. When these instances are carefully investigated the egg invariably proves to belong to the Cuckoo itself. Cuckoos, too, have been not infrequently shot as they were carrying a Cuckoo's egg, presumably their own, in their bill, and this has probably given rise to the vulgar but seemingly groundless belief that they suck the eggs of other kinds of birds"(40).

When we carefully investigate the habits of the Kohoperoa we do find that instances have been known of his eating an egg, but more often young birds, though this is a habit by no means universal, and no more common than in many other birds which are not credited with these villainous proclivities. The Native Kingfisher (*Halcyon vagans*), which preys on mice and small fish, &c., has been seen to attack and devour a fully adult Fantail (*Rhipidura flabellifera*), and fly off with several inches of tail-feathers protruding from its beak(40*a*); and the Thrush (*Turnagra crassirostris*) has similar propensities(35). The fact that our bird is so per-

sistently mobbed has called man's attention to it; but, like the Owl, she is saddled with regular habits which, when looked into, prove in a large number of instances to be absolutely false. According to Mr. Bosworth Smith, the Owl does very little robbing of nests at all, and is a cruelly maligned bird; and our Cuckoo gets the discredit of being far worse than it actually is because of the objection of other birds to its prowling round their nests. The female Cuckoo must place her egg in some nest, and each householder is determined that hers shall not be the domicile chosen if she or her mate can prevent it. Birds all the world over object to the intruding egg, and often throw it out of the nest, and this is the main reason, I think, for their hunting the Cuckoo. I have endeavoured to disprove the accusation against our bird; but, notwithstanding a strong opinion on my part that the tale was an idle one, I have had reluctantly to give way to good evidence. The following instances show that at our end of the world the Cuckoo has latterly acquired mischievous habits, which are, however, not to be wondered at, seeing the continued ill-treatment it has to put up with.

Many Cuckoos have been seen with fresh yolk smeared over their beaks and necks, and an instance of this was reported to me by a gentleman in Nelson Province(40*a*). This, of course, is not conclusive, as the yolk might well have belonged to an egg of the Cuckoo itself, which had been broken by the bird in an endeavour to place it in a nest. As a rule the information one gets is only circumstantial evidence. For example, the same man says, "My opinion is that they live entirely on small eggs and young helpless birds, but they are so shy and cunning that it is almost impossible to catch them at work; but I believe their thieving is done at night, as I have often found nests empty in the morning that contained eggs or young the night before, and you can hear their scream at all hours of the night"(40*a*). "We had a lot of trees in front of the house, and the Cuckoos used to come into the gums at night and scream, and all the Sparrows and other birds could be heard fluttering in the branches and making a great noise"(40*b*). "Frequently in summer, when it has grown dark, we hear cries of fright and anger from the small birds, and then the loud scream of the Cuckoo"(40*c*). "As to the Cuckoo robbing the nests of other birds, I have not seen one in the act, but have heard of lots of instances where nests have been found robbed of both eggs and young birds immediately after the Cuckoo has been seen in the neighbourhood, more especially the nests of the pretty little goldfinch"(40*d*). "I cannot say that I have actually seen it robbing a nest, but I have seen it very busy about Sparrows' nests in a

tree, and considered that that was what it was doing. The Sparrows were greatly excited, and followed it from tree to tree as it moved. My two boys say they saw eggs fall when the bird was so employed, and that one boy climbed the tree and found a mutilated nestling in the nest"(40*e*). "It can fly down any one of the small birds with the greatest of ease, picking it up in its claws when flying swiftly over it. It is very fond of going into smaller birds' nests and eating the young birds, but rarely stops to eat them near the nest, but flies off to a tree with its prey"(40*f*). A lady from Queenstown says, "One day I surprised a Cuckoo in a gully, and it flew off with a small object in its beak. A pair of Goldfinches seemed in great distress, and on searching I found the nest with a few feathers in it. The nest had apparently been recently occupied by young birds, though I am not positive of this, and I was not near enough to see the small object held by the Cuckoo"(40*g*). "I once saw in a paddock a strange bird which I took for a Sparrow-hawk. It was at the time eating a small bird, and it flew about 5 chains towards a gorse hedge. It appeared in its movements quite unlike an ordinary Hawk, otherwise I should not have noticed it. It did not rise high off the ground, but swooped along at a tremendous rate about 3 ft. off, and simply rose over the hedge without apparent wing-motion, and, I think, rounded on the other side"(40*h*). When ordinary food is scarce, as in early spring, and the birds have just arrived on the coast, they have to take what they can get, and are then carnivorous at times, for one of my lighthouse correspondents says, "The birds I saw were very much the colour of a Hawk spotted underneath, and with a very long tail, and flew very fast. There were half a dozen of them flying about, and I saw a Hawk and Seagulls chasing them. One I fired at had a small piece of rabbit—it looked like a leg—and it was pecking at it and flew off with it"(40*i*).

I now come to more positive evidence: "It is undoubtedly true that the Cuckoo robs the nests of other birds, as several members of our family witnessed last year. Our attention was attracted by a great commotion in the garden, and on going out we found two Blackbirds in a state of great excitement, uttering loud cries, and flying round a birch-tree. As we watched out flew a Cuckoo with a small bird in its beak; it flew into the orchard, and the Blackbirds chased it, dashing past it on one side and then the other, making an incessant noise"(40*j*). "I have seen a Cuckoo repeatedly with young birds in its bill, and have examined the nest after the Cuckoo has been at them, and have found nothing but the shell of the egg left. It chiefly robs Sparrows' nests"(40*f*). "I have seen one go into a red-pine tree and take from a hole in the trunk a young Sparrow, fly off into the scrub with it,

and in a short time return and repeat the performance with another nestling "(92). "Only last year I noticed one come out of a willow-tree from a Thrush's nest carrying a Thrush's egg in its mouth, the adult Thrush chasing it "(93). A Riversdale correspondent says, "I shot a very fine specimen as it was flying from out of a hedge of gorse, and it had a young Linnet in its beak, evidently just kidnapped "(94). "Last summer I saw a Cuckoo fly across the garden with a Thrush's egg in its beak, and two Thrushes in hot pursuit, uttering wild cries of distress "(99).

Mr. W. Milne, of Normanby, once saw his dog catch a Cuckoo alive and bring it to him. The Cuckoo had a full-grown Mocker (*Anthornis melanura*) in its claws. The latter was only just dead, was still warm, and the Cuckoo had already taken some pieces out of him, as the flesh was exposed and torn in several places(95). Mr. Riddle, of Orepuki, saw a Cuckoo chasing a number of Brown Creepers (*Certhiparus novæ-zealandiæ*). One of these the Cuckoo struck at and killed, and on attempting to pick the bird up from the ground at Mr. Riddle's feet was nearly captured by him(101). Sir Walter Buller's case of the Cuckoo which contained a Piopio I have already referred to. Mr. George Byers, of Stirling, wounded a Cuckoo with his "shanghai," and when the bird fell to the ground it vomited up three little unfledged birds(40*k*). Mr. Alfred Reynolds saw a Cuckoo one day in his garden at Riverton. It was eating an egg, which he thinks was that of a Thrush(40*l*). Mr. Gallien, of Winton, when preparing a Cuckoo for stuffing, found in its crop a complete young Sparrow, barely feathered. He also saw a Cuckoo on one occasion swoop on to a young Sparrow and fly away with it. At another time he saw a Cuckoo attack a Sparrow's nest, and, as far as he could see, either eat the eggs or young ones, while the old Sparrows were flying round, very much upset and making a great noise(40*m*). Mr. Charles Bills gives particulars of a Cuckoo dashing into his nets and attacking a Parrakeet so fiercely that it was taken while so engaged(40*n*). But there is no need for me to multiply instances. I have gathered sufficient to prove the occasional hawk-like carnivorous habit of the Kohoperoa. There is no doubt that he often robs Sparrows and other imported birds of their young and eggs; and this is very probably done by the male Cuckoo alone. The female Cuckoo, if ever a thief, is no fool, and almost certainly refrains from touching the eggs of birds in whose nests she deposits her progeny. There are very few instances of egg-robbing recorded, and those only since the introduction of English birds; and, as the natural food of the Cuckoo has become

scarcer, the bird has acquired the habit of helping himself from the nests of those who have largely been responsible for the diminished food-supply. Many of my correspondents say that the Cuckoo is now more common than it used to be, and attribute this to the abundance of imported birds. Thus Mr. Arthur, of Lawrence, "I have never seen it in dense, but always in thin bush, and along the edges of the bush, and especially in any patch standing out apart from the main bush, if frequented by a lot of small birds. The Cuckoo seems to have changed its habits during the last twenty years. Before that one heard them often, and saw them occasionally; but it was very difficult to get near them. Now they come into the trees in one's garden, and I have seen one in a clump of willow-trees not 12 ft. from my back door. I have no doubt that the change is caused by the importation of 'Home' birds of different habit from the native ones. Imported birds seem to live and breed in the vicinity of cultivated country, consequently, near townships, their nests and young are much more easily found, and are much more numerous than the native ones, and it seems to me that the Cuckoo is living on the eggs and young of these birds; and, as they are more numerous near dwellings and gardens, the Cuckoo also comes closer, and is more in evidence than it was. I may be wrong in my surmise, but I cannot see how the change in the habits of the bird can be otherwise accounted for. I think if the matter is gone into it will be found that the Cuckoo does the best he can towards combating the Sparrow plague"(40*o*). I am strongly of opinion that the Cuckoo seldom, if ever, touches the eggs of the Tui or the Mocker, its two chief enemies, and I should require very positive evidence before accepting this accusation as a true one. The Kohoperoa is often chased by these birds because they are frequently his unwilling foster-parents. The Waikato natives say that the Cuckoo lays its eggs in the nests of Tuis, but first eats the Tuis' eggs; similarly, the Urewera natives very naturally say that they know the Koekoea eats the Tuis' eggs because they see the Tuis chasing them. Mr. Crawford Anderson, of Stirling, saw an adult Kohoperoa sitting on the nest of the Mocker: the bird flew off as soon as he moved under the tree. The nest was rather difficult to get at, so he did not examine it for eggs(40*p*). Mr. Reynolds saw a Cuckoo being fed by a Tui, and the presumption is that it had been hatched in the Tui's nest, as the enmity between the birds is notorious, and one can hardly believe that the Tui would fail to recognise and attack its opponent, even though only half-fledged, were it not that it had hatched it out itself(40*q*).

Some writers assert that the Cuckoo excites the fury of her dupe by turning out one or more of the eggs, and in this

way assures more than ordinary(41) attention to the remaining egg or eggs. This is to my mind purely suppositious, for I can find but few instances of eggs being found on the ground beneath or near nests containing Cuckoo's eggs, and no proof that the Cuckoo herself has performed the eviction. There have, however, since the days of Jenner been numberless instances recorded of the young, blind, helpless, and unfledged Cuckoo instinctively wriggling under and deliberately striving to hurl, and eventually succeeding in hurling, to destruction the rightful tenants of the nest(42). It is indisputable that the Shining Cuckoo throws out the young Warblers, and I have myself found them on the ground beneath the nest containing the young intruder; and that the larger Cuckoo sometimes does the same is also undoubted(100).

Darwin says that "The offspring of the foster-parents of the European Cuckoo are commonly ejected from the nest within three days after the Cuckoo is hatched, although the latter is at this age in a most helpless condition. Trustworthy accounts have been received of the young Cuckoo, while blind and not able to hold up its head, ejecting its own foster-brothers. With respect to the means by which this strange and odious instinct was acquired, if it were of importance for the young Cuckoo to receive as much food as possible soon after birth I can see no difficulty in its having gradually acquired, during successive generations, the blind desire, the strength and structure, necessary for the work of ejection, for those young Cuckoos which had such habits and structure best developed would be the most securely reared. The first step towards the proper instinct might have been mere unintentional restlessness on the part of the young bird when somewhat advanced in age and strength, the habit having been afterwards improved and transmitted to an earlier age"(45*a*). In Mr. Smith's case the young Robins seem to have inherited an instinct that unless they kept to the bottom of the nest the young tyrant above them would speedily bring about their doom.

I should now like to review what evidence we have as to the migration of the Kohoperoa from the South Seas to these Islands. That it was known to the early colonists to appear annually, and as regularly to disappear, is shown by the startling statement made by the Rev. Mr. Taylor in his book "Te Ika a Maui," for he says, "The Long-tailed Cuckoo in the autumn buries itself in the mud of the river-beds, and there hibernates till the following spring"(46).

In the Rev. William Yate's "Account of New Zealand," published in 1835, he says, "This bird, which is remarkable for its long body and short cock's beak, is one of the sweetest

songsters of the woods, but it is only seen or heard for about four months in the height of summer. It secures itself during the winter months in the holes of the puriri-tree, and does not leave its retreat till all danger of its being overtaken with cold has passed away. The natives say that always when the wind is about to blow from the south the Kohoperoa ceases its song, and does not commence again until the west wind blows or a breeze springs up in the north." A good many of Mr. Yate's statements appear to have been got secondhand, for he has evidently confused the two Cuckoos. He says, "The Pipiwharauroa, or Shining Cuckoo, has no song at all," whereas we know it is the finest whistler we have in the Islands. He also says, "It is a bird of passage, and supposed to come from the islands north of New Zealand, though the natives assure us that it retires in the winter into the holes of trees or into the crevices of the rocks, and does not fly away for winter quarters to other and warmer climes"(48).

According to Mr. Elsdon Best, the Urewera natives say, "These birds disappear into the earth in autumn and come forth during the spring; we do not see them appear from the earth, but such was told us by our elders. Perhaps they retire to caves. They do not eat berries, but lizards, &c. There is no sign of the coming of this bird, as a wind or any other *tohu*—nothing but its cry; that is the only sign. We take the Koekoea for the sake of its *kotare*, or tail-feathers, which we prize as plumes for head-ornaments. I have not seen it eaten"(49*c*).

Mr. Taylor says the natives call it "Kawekawea" and "He piri rewa," the "Flying-lizard" or "Tree-lizard." The name Kawekawea may have been formed from the word *kaweau*, which means a "large lizard," or from a mere misspelling of the word *koekoea*, which has an entirely different origin.

Mr. Tregear says, "The natives have a curious fancy that the bird loses its feathers at the approach of winter, hibernating in holes in the ground. Its feathers begin to grow as spring advances, its tail drops off, and it again becomes a bird. In its lizard form it is called Gnaha at Taupo and Wanganui. To the native mind the green lizard is *moko kakariki*, a very fearsome creature, from its spiritual influences, and is the incarnation of a god. It is born from the shells left in the nest of the Kakariki, or Green Parrakeet, after the young birds are hatched out; but the Cuckoo is the child of a lizard that is mottled or speckled, and the name of this lizard is Mokotapiri or Gnarara-papa or Moko-papa"(49*a*).

The name Kawekawea may thus have arisen from the idea that the bird turns into a lizard; or it may be called the Tree-lizard from the peculiar mottled markings on the feathers, or from the fact of its appearing about the time that the

lizard casts its skin, which is similarly mottled. The name Koekoea is possibly formed from the word *koe*, to scream, and means the "Screamer," the word *koë* being evidently formed from the squeak or scream of any bird on being captured. It may have been applied to this particular bird from the peculiar grating whistle or whizzing sound that it makes. *Oë-oë* in the Hawaiian language means "to grate or whiz." "Koekoea," although so near in sound to the old Dutch "koekoek" and the English "cuckow," has no onomatopœic reference to the actual call of this bird, which at no time approaches the soft cooing of the Old-World Cuckoo. This onomatopœia is, however, well seen in many Maori words, as in "Kuku," the Wood-pigeon (*Carpophaga novæ-zealandiæ*), which makes a soft cooing sound; the high shrill calling Kea (*Nestor occidentalis*); the harshly screaming Kaka (*Nestor meridionalis*); and the sweetly whistling Piopio, or Native Thrush. The name "Koekoea" is used by the Urewera natives for "wanderers," or people who ever roam about, have no settled place of abode; and that the Maori recognises the significance of the parasitic habit of both Cuckoos is evident from many of his sayings or proverbs. "Penei me te Pipiwharauroa," "You are like the Shining Cuckoo" (in your actions—that is, You are no good, you desert your children). Again, "Te parahika te koekoea," a term used for a deserted child, means "the offspring of the Cuckoo"(49*b*). "E kua rite koe ki te koekoea," "You are exactly like the Cuckoo"—that is, You are a lazy fellow like the koekoea; you let other people feed you: a term of reproach used for an idle vagabond who "sponges" on others for his food. Referring to the hibernating of the bird, they say, "Ko enei manu e rua, ka hou ki roto i te whenua noho ai i te ngahuru": "These two birds dig their way inside the earth [under the soil] in the autumn." The following is a whakatakiri, or child's song, sung to an infant in arms:—

Ko te uri au i te whenakonako,
I te koekoea,
E riro ne i ma te tataihore e whangai:

"I am the offspring of the Bronze Cuckoo, of the Long-tailed Cuckoo, left here for the White-headed Canary to feed." When the call of the Bronze Cuckoo is first heard in the spring-time the children(49*c*) greet the bird with the following brief quatrain:—

E manu tena koe. Kua tae tenei ki te mahanatanga. Kua puawainga rakau katoa.
Kua pa te kakara ki te ihu o te tangata. Kua puta ano koe riinga, tioro ai.
Tioro i te whitu, tioro i te waru. Me tioro haere ano e koe tenei kupu e whaia
Ake nei, ki te marae o tama ma, o hine ma: Kui, kui, kui whiti-whiti ora.

O bird, greeting to you. The warm season appears and all trees have blossomed:
The fragrance reaches the nose of man. You again appear trilling on high.
Trilling on the seventh [month], trilling on the eighth [month]. Trill you ever forth as you fly
The following message to the homes of lads and lasses: Kui, kui, kui, whitiwhiti ora(105).

In other parts they say, "Ka tangi te Pipiwharauroa ko nga karere a mahuru"—that is, "The cries of the Shining Cuckoo are the messengers of warmth or spring"(49*c*).

Another and commoner name for the bird is Kohoperoa or Koehoperoa, the latter, I believe, the correct spelling, though the vowels are often variously transposed. The word is very probably formed from the words *koe*, *hope*, *roa*, meaning the "long tail"(106). Miss Sinclair, in her book of poems entitled "The Huia's Homeland," speaks thus of the Cuckoos:—

Hearken friends to this quaint idyll from the love-lore of the Maori,
From the ancient native records of the Rotorua beauty, of the beautiful wahine.
Hinemoa heard the birds sing in the bush all dark and dewy,
Heard the Shining Cuckoo's welcome to the tender flowers of springtime,
Pretty Pipiwharauroa, fostered by Te Riroriro,
Heard the Long tailed Swallow also, heard Te Koehoperoa,
In the winter-time a lizard, in the summer-time a swallow(50).

Sir Walter Buller tells us that, finding the birds arriving at the same time as the crane-flies, the Maoris say, "They come with the mosquitos"; and also from time immemorial the Maoris have called them "birds of Hawaiki." These facts, adds Sir Walter, "seem to indicate that they annually come from the warm islands of the Pacific"(51). In his essay in the first volume of our Transactions he says that they appear earlier at the extreme North, and linger there when their notes are no longer heard in the South. Like the Cuckoos in other parts of the world, they appear before rainy weather or coincident with it, and have thus come to be known in many widely different localities as "Rain-birds" and "Storm-birds." In many parts of Otago and Canterbury they were called by the early settlers "Potato-birds," as they invariably came on the scene as the potato-planting was going on; similarly, in the North Island they got the name of "Kumara-birds."

When the suggestion that they come all the way from the Pacific islands was first made by New Zealand ornithologists the statement was questioned by Mr. A. R. Wallace in the following words: "Resident ornithologists believe that the two New Zealand Cuckoos migrate annually, the one from Australia and the other from some part of Polynesia, dis-

tances of more than a thousand miles. These facts seem to have been accepted without sufficient evidence, and to be in themselves extremely improbable. It is observed that the Cuckoos appear annually in certain districts and again disappear, but their course does not seem to have been traced; still less have they been seen arriving or departing across the ocean. In a large and practically unexplored country there is really no reason why the birds should not recede from one end of the Islands to the other"(53, 52). From observations made in the last twenty years it is now certain that they do come from the South Sea Islands annually, and return there after breeding in New Zealand. How they persistently escape observation seems to me to be extraordinary, for I can find no instance of any person having witnessed the arrival of the bird from over the sea, as was reported of the Shining Cuckoo by Mr. Potts(57), and it is curious that no one seems to have found the bird on the sea-shore.

I have recently communicated with a number of the lighthouse-keepers on our coast-line, and have gathered some interesting information on this subject. The earliest intimation of the appearance of the bird this year comes from Mr. John Duthie, at Cape Palliser, who says that the first Cuckoo arrived on the 6th June, and six or seven a few days later. They hung about the lighthouse for six or eight weeks, and then suddenly disappeared the first week in August(57*a*). Mr. Hansen, from Pencarrow Head Lighthouse, reported that "one morning in the first week in September, exact day uncertain, when coming from the tower after putting out the light, at 6.30 a.m.," he saw a Long-tailed Cuckoo. The bird was flying low and swiftly, just skimming the tops of the tawhina scrub(57*b*). They have been seen at Doubtless Bay(57*c*), at Stephen Island Lighthouse(57*d*), at Hunterville, and on the Kermadecs(54), and at Akaroa about the middle of the same month. At Mokohinou Lighthouse Mr. Sandager caught several on the lantern at night in October(56), and Mr. Elsdon Best reported a young one at Ruatahuna on the 10th of that month. This was probably one which had wintered in the Urewera country, as it is rather early for the arrival of a last year's bird from Tahiti. The Maori who saw the bird said, "Wainehu ana te ahua," which means that the feathers were greyish or pale, the markings were not plain(49*c*). Mr. McNeill saw the birds at Cape Campbell Lighthouse in thick dirty weather at night in October(41): they have been frequently seen at Cape Farewell Lighthouse; East Takaka(40*a*); Nelson(97); Queen Charlotte Sound(102); Sumner and New Brighton(103); Waikouaiti, Otago(104); Riverton(40*l*); and Te Tua, Southland(107), in the second week in October: and I myself

saw the bird on the 20th and 25th October and subsequently in the bush at Newington, Dunedin. Reischek found them on the Barriers in November(55); and Mr. Byers, of Stirling, Otago, who has for years noted their arrival carefully, finds that they invariably come to his locality from the 5th to the 7th November(56*b*). That they keep on arriving from the north-east until about the end of November is shown by the fact of one being caught on the lighthouse at Cape Maria van Diemen at 5 in the afternoon of the 28th of that month. There was a strong easterly gale blowing at the time, and the barometer registered 29·83 in., the thermometer 63° Fahr. The bird was exhausted and quiet, but its plumage was fresh and not in any way draggled or weather-beaten(108). On the 4th December four female birds made their appearance on the lighthouse. They remained three days. The wind was light easterly; barometer 29·65 in., thermometer 65°. I have only noted the dates on which the birds were actually *seen*. I have numbers of references to their having been *heard* on various dates, from the 3rd September at Queenstown, the 4th at Winton, the 13th at Akaroa, the 28th at Te Kumu(109), onwards to the end of October at Waiau, Southland, and elsewhere; but as there is a possible doubt as to the accuracy of some of these reports I have relied on eye-witnesses alone. I heard what I took to be the call of the Cuckoo in the gum-trees opposite the University at 9 p.m. on the 19th October, and saw the bird next morning for the first time this year at Newington. Numerous other notes as to its arrival can be found in the pages of the "Transactions of the New Zealand Institute," and they all point to the advent of this mysterious bird from the north-east, probably in small parties and generally at night. I do not think it is yet clear that they always come gradually along the Islands from the extreme north, for they arrive suddenly at points so widely separated from each other that it is hard to account for this other than by the assumption that they come down in streams from the north-east and hit the coast-line of New Zealand at various places at about the same time. Mr. Witherby says, "On bright nights undoubtedly most migrating birds fly at a great height and pass over the lighthouses without being attracted by the light. It is on dark and especially misty nights that they come nearer to the earth and dash themselves against the lanterns. Birds run great and varied risks during their migration, and much mortality is the result. At the end of a long flight across the ocean they often encounter bad weather and heavy adverse winds, and many on such occasions become so fatigued that they never reach the land"(58). The Kohoperoa, having accomplished its spring migration, is fairly plentiful in most parts of the southern

portion of the South Island by November, and it may be noted that the first arrivals sit about among the trees or fly from tree to tree and are silent. Some say that this is due to the fact that they are all of the male sex; and the same observation has been made about the first arrivals of the Pallid Cuckoo in the southern parts of Australia(60). Nearly a century ago Colonel Montagu remarked that in the spring male Nightingales always arrived in England before the females, and since that time many observations have confirmed this statement concerning the Nightingale and many other birds. Herr Gatke has gone beyond this, and affirms that the forerunners of the spring migration to the north are invariably old males, next come the females, then younger males and females, and finally only birds of the previous year. Supposing these Cuckoos all start about the same time, it is conceivable that during the longest journey they would tail out, and the strongest birds, usually the males, obtain a lead(61).

In November the birds become active, and begin to utter their harsh grating "whiz-z-z-z-t." This grating whistle is no doubt the call between the sexes, and is uttered, it is probable, by the male alone. I am of opinion that in those cases where birds are heard calling from tree to tree, and apparently answering each other, the calls are really those of several males; but on this point I should like positive evidence. The birds keep to the tops of the tall pines and creeper-covered trees in the day-time, and are often hard to locate, and it is extremely difficult to decide whether a particular tree is the hiding-place. This is for two reasons, one that the bird, like its fellow-migrant the Shining Cuckoo, is endowed with what Sir Walter Buller calls "ventriloquistic powers"—that is, of increasing the volume of its notes from a very quiet call to a loud piercing succession of sounds, which performance produces exactly the impression that the bird is at first a long way off, and then gradually approaches the listener. Even when one has fairly decided that the bird is in a certain tree it is very hard to detect it with the eye, for the Kohoperoa has the habit of frequently perching along, instead of across, the branch, a method of concealment easy of performance to a bird with the characteristic zygodactyl feet of this family(40*a*).

The Kohoperoa likes the thickly foliaged English trees, which stand well out from the native bush—macrocarpas, firs, *Pinus insignis*, trees which are seldom frequented by our indigenous birds, and never inhabited by them. In this way the Cuckoo escapes a good deal of the incessant harrying which he used to undergo; and, besides this, these trees are especially suited to his peculiar modern appetite, as, in addition to the myriads of insects which infest them, Sparrows,

Linnets, and Greenfinches build their nests there in great numbers. From the shelter of these masses of foliage the Kohoperoa sends forth his extraordinary call, which is loud, penetrating, and very frequent during the early morning and forenoon, getting gradually quieter, uttered at longer intervals, and becoming very drowsy and low as noon approaches. It then ceases, and the bird probably sleeps for a few hours. The call is again uttered as evening approaches, and the Cuckoo becomes active and restless, getting ready to leave its retreat. The peculiar call is heard all through the summer nights, and is mistaken by many persons for the cry of the Smaller Owl, or Morepork (*Scelcglaux novæ-zealandiæ*). The cry of the latter, however, is quite distinct, being a weird purring sound, much more disturbing to the belated wayfarer who passes through the dense bush than the not unpleasant notes of the Cuckoo. On the other hand, a number of people mistake the thin grating whistle of the Green Linnet for the call of the Kohoperoa; but this also can be readily distinguished, as it is not nearly so loud, nor has it the ascending series of notes of the latter bird. Sometimes when the Cuckoo is chased by the Tui he will settle along a good-sized bough, and, turning towards his pursuers, make a curious defiant crowing sound(90*b*). And it has yet another cry, difficult to describe, which is only heard at night when the bird is flying low among the trees. This is a queer sort of rattling noise, something between the curious chuckle of the Kaka and a very quick clucking of the Hen (*Gallus domesticus*)(38*q*).

The moment our Cuckoo shows itself in the day-time it is pounced upon by all the small fry in the way of native birds, who pursue and torment it until it reaches the safety of long grass or thicket once more.

It flies with a peculiar swooping movement at times, and by some observers is credited with strong volant powers; but, as it is only seen on the wing for a few seconds at a time, little is at present known of this. The flight is peculiar, with a very rapid motion of the wings, and Mr. Potts says that "it flies but a short distance at a time, and in the young bird the flight is awkward; the bird alights heavily on the ground, turning each time it settles so that it faces the direction from whence it flew"(62). This is a curious habit; can any one suggest an explanation? Can it in any way be an indication in the young bird of turning toward or against the wind, and does it afford any clue towards the elucidation of the migratory instinct? Is it, on the other hand, an indication in the young bird of an instinctive turning to face its enemy, a feeling that the instant it alights it should turn its face to its foes? Is this the same instinct which causes the bird when it perches on a branch to immediately turn sideways along it, partly to assist

in concealment, but also perhaps to get another bough alongside it, leaving only one side visible and unprotected?

In watching the bird this year in the Newington bush I have been struck with its Pigeon-like aspect. On leaving a tree it first falls with little wing-motion, but more of a swoop, to about 20 ft. from the ground, and then with a very rapid regular motion of the wings proceeds with incredible speed through the air; suddenly, with the least little cant to one side, and slight spreading fanwise of the tail, it turns in an instant at right angles to its original course and is off like an arrow in the new direction, with its long tail streaming out behind it; then, with another quick swoop upwards, reaches its perching-place, where, just as it settles with a little flutter, the tail is again slightly fanned. I have the excellent authority of Mr. Elsdon Best for saying that when the Cuckoo is struck at by the Tui he instantly turns over, doubles back, and thus escapes; this, his Maori informant says, is never seen save when the Cuckoo is attacked in the air by the Tui. The same native says that he has seen as many as five Cuckoos flying slowly in a line, one after another, each one a little higher than the one just preceding it. These birds were evidently migrating; and Mr. Arthur, of Lawrence, gives the same curious piece of information, "I have seen them high in the air, as if arriving or leaving for long flight. The flight is not nearly so fast then, the wings not being moved so quickly as when amongst trees"(40*o*). Burroughs says of the American Yellow-billed Cuckoo that "it has certain peculiarities that remind one of the Passenger Pigeon; his eye with its red circle, the shape of its head, and its motions on alighting and taking flight quickly suggest the resemblance, though in grace and speed, especially when on the wing, he is far inferior. His tail is disproportionately long, and his flight among the trees very still, contrasting strangely with the honest clatter of the Pigeon"(38*c*).

Many of the larger Cuckoos have extraordinarily long tails, and this has often been pointed out with respect to the Indian, American, European, and Australian birds; so with our own bird the same disproportionate appendage is displayed. Now, there must be something more than mere sexual adornment in this, and it has appeared to me that, as Cuckoos are universally mobbed by other birds, on account of their parasitic habit, the long tail is a protective adaptation of structure—in other words, a "provision of nature" to allow of rapid turning in the air, as an aid in obtaining insect food and as a means of escape from its tormentors. Brehm says of the European Cuckoo that "it will dart round corners with the rapidity of an arrow, between bushes and through branches with the greatest address; it rarely, however, cares to traverse a large

space at a time"(12*a*). Bendire says of the American Cuckoo, "It can dart at full speed through trees, between boughs, and round corners as quickly as though in clear open space"(38). Mr. Arthur, speaking of our own bird, says that "its flight is rapid, and that it usually flies in a direct line from point to point without any turning, unless pursued by a Tui, when it can turn amongst trees at an amazing speed"(38*b*). This long tail may be of service if spread fan-wise during the long flight, enabling the Cuckoo to rest its wings by soaring for a time, and that it is fanned on alighting I have already mentioned; but to my mind the "steering-oar" is its main function. The Sparrow-hawk, which it greatly resembles, spreads his fan when soaring in the air(20), though his tail is not nearly so long in proportion to the size of the bird, but he has the faculty of very rapid wing-motion and quick steering for matters of offence; and in the same way the Long-tailed Goatsuckers of Africa utilise their tails when on the wing after small insects(12*a*). The beautiful little Fantails, of our own Islands, also show the same marvellous turning and doubling in the air, and in their case undoubtedly utility is as much the cause of their wonderful appendage as is mere sexual adornment.

Our Kohoperoa being semi-nocturnal, like the Cuckoo elsewhere, is noiseless in its flight, and this is, no doubt, the main reason for the success the female achieves in getting her eggs into the nests of other birds. So far as I can find, no one has been fortunate enough to witness this, though it is undoubted that it must take place during the day-time, when the builders are absent or have been driven from the nest. Many eggs must be lost in attempts at deposition, a large number probably swallowed or broken by their owners, others dropped on the ground. From what I hear of strange eggs in imported birds' nests, it is likely that the Cuckoo is now beginning to make use of them as homes for her young, though the Robin, Canary, and Tom-tit, less frequently the Tui and Mocker, are the best-known sufferers.

The following is a list of reputed foster-parents and of birds which have been seen feeding the Cuckoo, with name of observer:—

Gerygone flaviventris. Egg not described taken from nest. W. W. Smith.

Gerygone flaviventris. Bird seen feeding young Cuckoo. Buller and others.

Myiomoira albifrons. A round egg, deeper in colour than the one in the Christchurch Museum. Smith. From this egg hatched out in due course the Long-tailed Cuckoo.

Myiomoira albifrons. Young bird fed by the Robin. R. Riddle.

Myiomoira macrocephala. Bird seen feeding the Cuckoo. H. Robinson, Akaroa.

Myiomoira macrocephala. Koekoea found in the nest of the Tomtit. Westenra.

Myiomoira macrocephala. Egg reddish-purple, &c. (*vide* ante). John Ross's assistants, W. Millar and A. Pittaway.

Orthonyx albicilla. Bird seen feeding young supposed to be that of *Glaucopis cinerea.* Buller's Maori informant.

Orthonyx albicilla. Cuckoo in nest fed along with young Canaries. Elsdon Best's Maori informant.

Orthonyx ochrocephala. Young Cuckoo found in nest. R. Riddle, Orepuki.

Orthonyx ochrocephala. Young Cuckoo seen among flock of Canaries. McLean.

Carpophaga novæ-zealandiæ. Bird seen feeding fully fledged Cuckoo. R. Riddle.

Certhiparus novæ-zealandiæ. Bird seen feeding young Cuckoo. R. Riddle.

Prosthemadera novæ-zealandiæ. Waikato natives. No details given.

Prosthemadera novæ-zealandiæ. Tui seen feeding young Cuckoo. A. Reynolds.

Anthornis melanura. Cuckoo seen sitting on nest. Crawford Anderson.

Zosterops lateralis. A long egg of dark colour, tapering to one end, about $1\frac{1}{4}$ in. in length. Cuckoo seen coming out of tree. McLean.

There are several other nests which have been reported to me as containing eggs belonging to this bird, but I have received no details in time for this paper. Of imported birds Mr. Jules Tapper, of Clifden Station, has kindly allowed me to examine an egg taken from the nest of the Brown Linnet. There is no doubt of the identity of the egg, as he saw the Cuckoo sitting on the nest. There were two Linnet's eggs in the nest. The egg is almost the same in size and colouring as the one found at Milford, and is described as oval, $\frac{3}{4}$ in. in length, light brownish-pink, with brown blotches. The Grey Linnet is also considered a host, as a large white egg over an inch long was taken by Mr. Geo. Byers, jun., from the nest of that bird. Large white eggs have also been reported from the nest of the House-sparrow, possibly belonging to the Cuckoo. In November and December the bird is laying, and young Cuckoos appear in January and February. It is probable that they lay well on in the season, as I have heard them calling

loudly in the Dunedin Town Belt as late as the 12th February. Professor Benham saw some making a disturbance in the tops of some *Pinus insignis* in the Rangitata district in February of last year, and I saw several disporting themselves in the garden of the late Mr. Robert Gillies on the 7th February, 1897. Captain Mair tells us that he has seen them in flocks on the Hurukaureo River in February, and this is another point deserving of attention, to which I shall refer later on(63). The Cuckoo at Milford Sound seems to have laid as late as the middle of January, and, giving a month or six weeks, the nearly adult birds would appear about March. The young, being distinctly spotted on the back, are readily distinguished from the adult.

About February or March they begin to disappear from Otago, some receding gradually north, others probably leaving direct, the young ones remaining till the last. Mr. McLean, of Te Tua, says, "Several years ago, some time in February, I saw a number of them — there must have been over a dozen — assemble on some trees near Orepuki one morning. This was the first time I had ever seen such a thing. I was passing at the time, and when I returned they were gone, in what direction I do not know, but as I did not see any more that season I presume they were preparing to migrate. Mr. Tapper, of Waiau, in March, 1902, saw as many as nine or ten Cuckoos in the gum-trees near his house, within a distance of 20 yards, and they were making a great noise amongst themselves(101). Mr. Byers, of Stirling, informs me that "one morning in early February I saw six Cuckoos all on one tree together; they were making a great noise, not their usual long-drawn-out chirp, but a twittering call; my impression was that they were mustering their forces for migration "(38*n*). From this it will be seen that they do not always recede gradually northwards, but are often seen in the autumn assembling in flocks and suddenly disappearing, and I am of opinion that in many cases they start off on their return journey direct from any one point in New Zealand, and that when once they have risen into the air they probably do not alight until they have reached their tropical home. Mr. Smith, of Lake Brunner, says that they arrive in that neighbourhood about the first week in October and leave about the middle of March(64). Hamilton records an instance of the bird being seen in the Petane Valley, Hawke's Bay, the last week in March, and asks whether any evidence is to be had as to its wintering there(65). To this query I may say that a young one was seen at Queenstown in April, 1902, and its plaintive cry was heard from day to day up till the 5th May(40*j*). Travers mentions an instance of one being shot at New Plymouth in

June, and suggests that some spend the winter with us(66). Buller thinks this unlikely, save on very rare occasions; but, commenting on the good condition of this bird, expresses himself as astonished at the need for migration when there is evidently in New Zealand abundance of winter food for the Cuckoo(67). That the birds migrate here for breeding purposes alone, and not for food, which must be ample in the tropical islands of the Pacific, is now quite certain(81). Cheeseman, quoting Bell, of the Kermadecs, says that the birds are annual visitants there, though by no means common(68); but in a subsequent volume of the Transactions quotes, from the same informant, that the bird is a permanent resident of that island(69). Kirk states that both the Long-tailed and Shining Cuckoos may occasionally be seen in New Zealand all through the winter season(70). Sandager says that two wintered at Mokohinou in 1888(71). There is little doubt that the birds reported to me this year from Cape Palliser had wintered near there, visited the neighbourhood of the lighthouse, stayed for a few weeks, and then left for their breeding-haunts in the south(40*i*). A correspondent from the Bay of Plenty tells me that he has known of their having been seen in the bush there in the winter-time(71*a*). Mr. McLean, of Te Tua, Southland, assures me that one was heard there all through the winter of 1903, and that he had never known of such a thing before. They are to be found on the Chatham Islands and the Auckland Islands, according to Travers, but I can find no details of their arrival or departure therefrom(72); in New Caledonia in March and April(73); and in the Solomon Islands in April and May; and, as Captain Hutton says, the evidence is strong that they leave New Zealand in the autumn and travel north-west to the tropical islands of the Pacific(75). Finch and Hartlaub give Fiji(74), Marquesas Islands, Tonga, Samoa, Cook Islands, and New Zealand as their habitat, and we can now accept as certain that these birds, which are often referred to as being feeble in wing-power, twice annually perform the extraordinary feat of flying through the air for a distance of over a thousand miles before obtaining rest for their weary pinions.

Before concluding I should like, in a few words, to give some suggestions as to how the habit of parasitism in birds has become established. What is the reason for this extraordinary habit of imposing eggs upon other birds? Why this utter neglect of parental responsibilities? Among other parasitic birds known to science are *Molothrus*, or Cowbird, of America; *Cassidix*, or Rice Grackle, of South America; and *Indicator*, or Honey-guide, of South Africa; and among these species are to be found all the stages between true nest-building and true parasitism. The generally accepted idea

is that set out by Darwin — that the occasional laying of an egg in another bird's nest may reduce the work of tending a very large brood, and be of service to the parent in enabling her to migrate earlier; and at the same time the mistaken instinct of the host may make the young more vigorous than if fed by its true parent, and thus prove of advantage. That the eggs are laid at considerable intervals of time was thought by Darwin to have increased the difficulty of self-hatching, and to have helped to advance the onset of parasitism. On carefully looking into the habits of all of these parasites the most important point that strikes one is the universal prevalence of promiscuous breeding and polyandry—that is, of the occurrence of small flocks of five or six cock birds and only one hen(113). What is the cause of this preponderance of males is the key to the mystery. The only reason the writer can find is the fact that during migration the strongest birds, usually the males, obtain a lead, and are known always to arrive first in any one locality. Male Cuckoos, silent for days or weeks, are seen in Australia and elsewhere, and it is only on the arrival of the females that they begin their calling. That there are non-migrating parasitic Cuckoos in India and many non-parasitic migrants everywhere makes it certain that there are other causes as well for this preponderance of males, but that migration is one of them seems feasible. Now, taking these birds with their peculiar habits of breeding, there is no pairing in the true sense of the word, though it is undoubted that the assistance of both male and female is necessary in the construction of a nest. Wallace tells us that the male bird of a pair, often a young one, may learn from his mate, who has had previous experience of nest-building, and, *vice versâ*, a young female is often helped by an old male bird and a very neat nest constructed. On the other hand, a pair of young birds new to the business often construct a very poor habitation indeed. The female Cuckoo or Cowbird, whose companions roam about the bush, has no mate to help her, her feet and bill are ill-adapted for nest-construction, so she is either content with a few poor sticks on which she lays her eggs or else she drops them one by one into the nests of other birds. In order to make this the more easily effected she has acquired the faculty of irregular egg-laying, so that her chicks are hatched out at intervals of several days, a habit also seen in our Native Harrier (*Circus gouldi*) and in our Shags (*Phalacrocorax*). Male Cuckoos and Cowbirds are always in the majority, especially at the beginning of the breeding season, and, for reasons before mentioned, this may be partially due to the long flight of migration. From lack of domestic habits and assistance of the male bird the female has not acquired the

faculty of nest-building, save in a very rude, flimsy form, or in a great combined clumsy structure in which a number of females lay. Cowbirds and Cuckoos show all the stages between true nest-building and parasitism. Some of the American Cuckoos and Cowbirds and our own and the Old-World Cuckoos, having probably passed the stages of nesting in common and of depositing their eggs in common "boarding-houses," but retaining the habit of irregular ovipositing, find it expedient, in order to be ready for the return autumn migration, to drop their eggs one by one into the nests of other birds.

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(40*q*) „ Mr. Alfred Reynolds, Riverton, 24th September, 1903.
(41) Encyclopædia Britannica, 9th ed., vol. iii., p. 772.
(42) A Dictionary of Birds (Newton), pt. i., p. 126.

(43) The Birds of India (Jerdon), vol. i., p. 321.
(44) The Century Dictionary, 1902 ed., vol. v., p. 3825.
(45) Nests and Eggs of Australian Birds, vol. ii., p. 591.
(45*a*) Origin of Species, 6th ed., chap. viii., p. 215.
(45*b*) *Ibid.*, p. 216.
(45*c*) Naturalist's Voyage round the World (Darwin), p. 75.
(45*d*) Origin of Species (Darwin), p. 214.
(46) Te Ika a Maui (Rev. R. Taylor, 1870), p. 45.
(47) *Pearson's Magazine*, April, 1903, p. 357.
(48) An Account of New Zealand (Rev. William Yate, 1835), p. 65.
(49) A Dictionary of the Maori Language (E. Tregear).
(49*a*) Letter from Mr. E. Tregear, Wellington, 1st July, 1903.
(49*b*) Dictionary of the Maori Language.
(49*c*) Letter from Mr. Elsdon Best, 8th October, 1903.
(50) *New Zealand Illustrated Magazine*, April, 1903, p. 213.
(51) A History of the Birds of New Zealand.
(52) Geographical Distribution of Animals (Wallace), vol. i., p. 452.
(53) Trans. N.Z. Inst., vol. i., p. 13.
(54) *Ibid.*, vol. xx., p. 154.
(55) *Ibid.*, vol. xiv., p. 274.
(56) *Ibid.*, vol. xix., p. 181.
(57) *Ibid.*, vol. xxii., p. 288.
(57*a*) Letter from Mr. John Duthie, Cape Palliser, 10th September, 1903.
(57*b*) Letter from Mr. Anders Hansen, Pencarrow Head Lighthouse, 15th September, 1903.
(57*c*) Letter from Mr. Charles Hertslet, Doubtless Bay, 23rd September, 1903.
(57*d*) Letter from Mr George Jamieson, Stephen Island Lighthouse, 14th August, 1903.
(58) *Pearson's Magazine*, April, 1903, p. 362.
(59) A History of the Birds of New Zealand, vol. i., p. 131.
(60) Nests and Eggs of Australian Birds, vol. ii., p. 564.
(61) *Chambers's Journal*, 3rd May, 1902, p. 410.
(61*a*) Birds of India (J. C. Jerdon).
(62) History of the Birds of New Zealand, vol. i., p. 131.
(63) Trans. N.Z. Inst., vol. iii., p. 91.
(64) *Ibid.*, vol. xxi., p. 213.
(65) *Ibid.*, vol. xviii., p. 123.
(66) *Ibid.*, vol. xxxi., p. 17.
(67) *Ibid.*, vol. xxxi., p. 17.
(68) *Ibid.*, vol. xx., p. 154.
(69) *Ibid.*, vol. xxiii., p. 219.
(70) *Ibid.*, vol. xxviii., p. 8.
(71) *Ibid.*, vol. xxii., p. 288.
(71*a*) Letter from Mr. Campbell Thomson, Opotiki, 2nd October, 1903.
(72) Trans. N.Z. Inst., vol. xv., p. 187.
(73) *Ibid.*, vol. xxxiii., p. 258.
(74) Ornithologie de Vitis (Finsch and Hartlaub), p. 27.
(75) Trans. N.Z. Inst., vol. xxxiii., p. 258.
(76) Encyclopædia Britannica, 9th ed., vol. iii., p. 772.
(77) Trans. N.Z. Inst., vol. v., p. 235.
(78) *Nature*, vol. x., p. 459.
(79) A Dictionary of Birds, part ii., p. 568.
(80) Encyclopædia Britannica, vol. iii., p. 769.
(81) Trans. N.Z. Inst., vol. xxxiii., p. 258.
(82) A Dictionary of Birds, part ii., p. 568.
(83) *Ibid.*, part ii., p. 569.
(84) History of British Birds (Bewick), Memorial Edition, 1885, vol. i.

(85) Cuckoos and Shrikes in relation to Agriculture (Merriam), p. 11.
(86) The Birds of India (Allan Hume), vol. i., p. 135.
(87) Proc. Zool. Soc., 5th January, 1892, pp. 270–71.
(88) Ibis, vol. for 1900, p. 640.
(89) Ibis, vol. for 1897, p. 363.
(90) Letter from Mr. John White, Dunedin, 9th October, 1903.
(91) " Mr. John McNeill, Cape Campbell, 12th November, 1903.
(92) " Miss Frew, Edendale, 26th November, 1903.
(93) " Mr. R. Riddle, Orepuki, 16th November, 1903.
(94) *Otago Witness*, Notes and Queries, 9th December, 1903.
(95) Statement of Mr. W. Milne, Normanby, 10th December, 1903.
(96) Ibis, vol. for 1902, p. 587.
(97) Letter from Mr. R. G. Sparrow, Nelson, 22nd October, 1903.
(98) " " " " "
(99) " Mr. James McLean, Orepuki, 26th November, 1903.
(100) " Mr. R. Riddle, Orepuki, 16th November, 1903.
(101) " Mr. Jules Tapper, Waiau, 20th November, 1903.
(102) " Miss Beauchamp, Anakiwa, Picton, 22nd November, 1903.
103) " Lighthouse-keeper, Akaroa, 16th November, 1903.
(104) " Mr. Allan Orbell, Waikouaiti, 16th November, 1903.
(105) " Mr. Elsdon Best, Ruatahuna, 12th December 1903.
(106) " Mr. Edward Tregear, 1st July, 1903.
(107) " Mr. John McLean, Te Tua, 26th November, 1903.
(108) Telegram from Mr. A. Voyle, Cape Maria van Diemen, 30th November, 1903.
(109) Telegram from Mr. Norman Fulton, Te Kumu, Hunterville, 30th September, 1903.
(110) Ibis, vol. for 1902.
(111) Birds of the North-west (Elliott Coues).
(112) Bendire's Life-history of American Birds.
(113) Trans. Aust. Assoc. for the Advancement of Science, vol. for 1904.

Art. IX.—*Description of a New Fish.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Bovichiths rosec-pictus, sp. nov.

Head and body slightly compressed. The total length about 5½ times the height of the body and 4½ times the length of the head. The top of the head is smooth, with two small ridges, and it descends abruptly in front of the eyes, which are lateral. The diameter of the eye is about equal to the length of the snout, and is more than the inter-orbital space. Operculum with a long straight spine; the other bones of the head unarmed. Pectoral fins rather pointed, as long as the head, the lower five rays slightly thickened. Ventrals jugular, remote at their bases, pointed, nearly as long as the pectorals, the spine soft. Dorsals separate; the first about half the length of the second; neither of them so high as the body. Anal rather shorter

than the second dorsal. Caudal apparently truncated. No scales. The lateral line well marked, continuous, rather rough. Minute teeth on the jaws and palate.

Dark olivaceous-brown on the back, the sides and abdomen silvery, with a pink spot at the base of the operculum and five bright rose-pink bands on each side.

D., 8/18(?); A., 13(?).

Total length, 46 mm.; of the head, 10 mm.; of the snout, 3 mm. Height of the body, 7·5 mm. Diameter of the eye, 3·5 mm.; interorbital space, 3 mm. Length of the base of the first dorsal, 6·5 mm.; of the second, 13 mm.; of the anal, 11 mm. Length of the pectoral, 10 mm.; of the ventral, 9 mm.

Picked up on the beach at Sumner and presented to the Museum by Mr. F. C. B. Bishop.

As the fish had been partially dried I could not count the fin-rays very accurately, but it is evident from its colours that it is distinct from any previously described species.

The type is preserved in the Canterbury Museum.

ART. X.—*On the Occurrence of* Centrolophus *in New Zealand.*

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Centrolophus, called "blackfish" from its colour, is a pelagic fish found in the Mediterranean and North Atlantic. Early in the year 1893 the Australian Museum at Sydney received a specimen from New Zealand which was described by Mr. Douglas Ogilby as a new species, *C. maoricus*. On the 16th of last February another specimen of the blackfish was picked up at Sumner by Mr. Thomas Clark, who presented it to the Christchurch Museum. The specimen was considerably damaged by gulls about the head and neck, but it has been preserved in formalin.

It differs from *C. maoricus* in the more numerous fin-rays, in which respect it comes nearer to *C. britannicus* of Dr. Gunther (Ann. Mag. Nat. Hist., 3, vi., 46), but our fish has more fin-rays even than that species. However, without making a skeleton it is difficult to say exactly where the dorsal fin begins or how many spines it has, for it rises so slowly from the back and the spines are so weak.

The following is a description of the specimen:—

D., 10/47; A., 3/35.

Greatest depth goes $5\frac{1}{4}$ times into the total length. The length of the head goes $5\frac{1}{2}$ times into the total. The maxillary reaches to below the front of the eye. The dorsal fin is low and the rays are feeble; it commences above the base of the pectoral.

The scales are minute, and form a sheath along the basal half of the vertical fins.

Colour, dark-brown, without any spots.

Total length, 34 in.; length of the dorsal fin, about 20 in. or 21 in.; of the anal, 11 in.

Art. XI.—*Revision of the New Zealand Members of the Genus* Phorocera.

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

In the New Zealand species of the genus the macrochætæ are generally as follows: Vertical bristles, one pair on each side, slightly diverging. Ocellar bristles present. Fronto-orbital in two rows, the inner 6, the outer 3, stronger. Lower fronto-orbital also 4, descending to about the middle of the eye. Facial bristles on the lower two-thirds of the ridges; a strong vibrissa near the mouth. Humeral bristles, 3; post-humeral, 2. Dorso-humeral, four rows on each side. Scutellar bristles few, about 6 on each side, pointing backwards. Meso-pleural in a vertical band, the posterior not strong. Ptero-pleural, 2; sterno-pleural, 1, very strong. The first, second, and third abdominal segments are without discal bristles in the female. The second segment has two marginals near the centre. The third segment has several; and the fourth has both discal and marginal bristles.

P. atrox.

The sides of the face are yellowish-white; the antennal groove is pure-white.

P. perniciosa.

The sides of the face are greyish-white, with a brown spot; the antennal groove is white.

P. nyctemeriana and **P. feredayi.**

I have no more information about these species.

P. nefaria.

There is a mistake in my former paper in Trans. N.Z. Inst., xxxiii., p. 59. There is no yellow spot at the base of the wings.

P. aurea, sp. nov.

Frontal band black; vertex black, with blue reflections; sides of the face golden-yellow, with a reddish-brown spot on each side just below the lower fronto-orbital bristles. Antennæ, antennal fovea, and proboscis black. Thorax, scutellum, and abdomen brilliant metallic-blue. Legs black. Squamæ greyish. Wings colourless; the veins black, the costa fulvous at its base. First posterior cell open. No discal setæ; marginal setæ on the third and fourth segments only. Length, 7 mm.; wing, 7 mm.

Longbeach, November, 1902.

P. marginata.

This species has a brown spot on each side of the face. The individuals with a green thorax I make into a separate species, as follows:—

P. exitiosa, sp. nov.

Frontal band and antennæ black, as also are the palpi and proboscis. Vertex dark-grey. Cheeks black, with silvery pubescence. Thorax metallic-green; the abdomen deep-blue. Scutellum blue, margined with ferruginous. A rather obscure fulvous spot at the base of the wings. Legs black. Length, 8–9 mm.; wing, $6\frac{1}{2}$–$7\frac{1}{2}$ mm.

Longbeach, November, 1902.

There are 3 sterno-pleural macrochætæ.

P. tecta, sp. nov.

Frontal band dark reddish-brown; vertex and sides of the face yellowish-white, with a spot of reddish-brown on each side about the middle of the antennal groove. Antennæ, palpi, and proboscis piceous. Thorax grey, with three short black lines on the fore part. Scutellum dark-fulvous, the base grey. Abdomen greyish-brown, with white tessellations on each side. Legs blackish, the tibiæ dark-fulvous. Squamæ white. Wings colourless; the veins blackish-brown. The first posterior cell completely closed. Three sterno-pleural macrochætæ. Length, 7 mm.; wing, 5 mm.

Wellington and Christchurch.

P. casta, sp. nov.

Frontal band dark reddish-brown; vertex and sides of face silvery-white, without any spot. Antennæ and proboscis piceous. Thorax greyish-brown, with some obscure black lines

on the fore part. Scutellum fulvous, with a grey base. Abdomen dark greyish-brown, with white tessellations on the sides. Legs blackish, the tibiæ dark-fulvous. Squamæ white. Wings slightly tinged with brown near the base; the veins dark-brown. The first posterior cell barely closed. Length, 7 mm.; wing, 5 mm.

Christchurch.

P. inconspicua, sp. nov.

Like *P. tecta,* but no spot on the side of the face, and the first posterior cell slightly open. Third joint of antennæ not much more than twice the length of the second. Length, 7 mm.; wing, 5 mm.

Christchurch.

Described from a single specimen.

P. orasus.

The sides of the face are yellow, the antennal groove white. Legs black. Length, 7 mm.; wing, 5 mm.

P. clathrata.

This species differs from *P. orasus* only in having red spots on the sides of the abdomen, and there are many intermediate varieties of which it is doubtful to which species they should be referred.

P. efferata.

Frontal band dark reddish-brown; the vertex yellowish-white, with black shadows; sides of the face yellowish-white, with a broad brown spot on each side half-way down the antennal groove. Femora tawny; tibiæ and tarsi black. Often a fulvous spot on the side of the second abdominal segment. Three sterno-pleural macrochætæ. Length, 10 mm.; wing, $7\frac{1}{2}$ mm.

P. fulvipes, sp. nov.

Like *P. efferata,* but the tibiæ and tarsi fulvous. Length, from 8 mm. to 10 mm.

P. brouni, sp. nov.

Vertex, face, and antennæ black. Thorax and scutellum dark-fulvous. Abdomen pale-fulvous. Legs black. Wings colourless. Length, 5 mm.; wing, 4 mm.

Maketu. Captain Broun.

A single damaged specimen, but very distinct from any other.

P. funesta.

There is a brown spot on each side of the face.

The following key to the species may be useful :—

1. Abdomen æruginous.
   - Face yellowish-white .. .. *atrox.*
   - Face greyish-white .. .. *perniciosa.*
2. Abdomen pure-blue.
   - Scutellum brown.
     - First abdominal segment brown .. .. *feredayi.*
     - First abdominal segment blue .. .. *nyctemeriana.*
   - Scutellum entirely blue.
     - Face dark-grey .. .. *nefaria.*
     - Face golden-yellow .. .. .. *aurea.*
   - Scutellum margined with red or brown.
     - Thorax blue .. .. *marginata.*
     - Thorax greenish .. .. *exitiosa.*
3. Abdomen brown, tessellated with white.
   - A reddish-brown spot on each side of the face.
     - First posterior cell distinctly closed .. .. *tecta.*
     - First posterior cell more or less open.
       - Femora black.
         - Abdomen with red spots .. .. *clathrata.*
         - Abdomen without spots .. .. *orasus.*
       - Femora tawny.
         - Tibiæ and tarsi black .. .. .. *efferata.*
         - Tibiæ and tarsi tawny .. .. .. *fulvipes.*
   - No spot on the side of the face.
     - Third joint of antennæ more than three times the length of the second .. .. .. *casta.*
     - Third joint of the antennæ less than three times the length of the second .. .. *inconspicua.*
4. Abdomen pale-fulvous .. .. *brouni.*
5. Abdomen black .. .. *funesta.*

ART. XII.—*Two New Flies.*

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Limnia castanea, sp. nov.

Vertex and antennæ dark chestnut-brown; frontal band nearly black; face and fore coxæ silvery. Thorax tawny on the top; the sides dark-brown, with a broad silvery longitudinal band. Abdomen dark-tawny. Halteres tawny. Legs tawny, the tibiæ and joints of the tarsi tipped with dark-brown. Wings pale-yellowish, with brown spots; the marginal cell with four spots outside the subcostal cell, and two smaller ones inside it. The submarginal and first posterior with ocellated spots, the ocelli of two adjacent spots often running together. The other cells with simple spots and bands; the cross-veins slightly margined. Length, 7 mm.; wing, 7 mm.

Wellington.

Allied to *L. obscura.*

Limnia striata, sp. nov.

Vertex and antennæ bright-tawny; frontal band the same or darker; a transverse band, just above the antennæ, brown. Thorax pale-yellowish, with four longitudinal dark-brown bands, the two middle ones rather approximated; the sides yellow. Fore coxæ and sides of the face white. Halteres tawny. Abdomen brown. Legs tawny, the tibiæ slightly tipped with brown; the hind tarsi dark-brown; sometimes the middle tarsi are also dark-brown. Wings nearly white, with brown spots; the marginal cell with four large spots outside the subcostal cell and two small spots inside it. These are not ocellated. Submarginal and first and second posterior cells with ocellated spots. The other cells with simple spots; cross-veins broadly margined. Length, 5 mm.; wing, 5 mm.

Longbeach, among grass near the sea.

Art. XIII.—*On a New Weta from the Chatham Islands.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Pleioplectron serratum, sp. nov.

Joints of the antennæ cylindrical in both sexes, broader than long near the base. Pronotum and mesonotum not margined. Fore and middle femora unarmed below; the hind femora with fifteen teeth below in each row, those of the outer row smaller than those of the inner; fore and middle tibiæ with three pairs of spines below, none above; hind tibiæ slightly grooved above, with 16 to 20 red spines, nearly regular in size. Subgenital plate of the male transverse, with a long stout process, rounded at the end, between the styles. The subgenital plate of the female is hidden.

Colours, fuscous-brown, the face and palpi pale; antennæ fuscous. No pale line on the pronotum. Legs pale-yellowish, the hind femora usually with some fuscous markings. Total length of the male, 32 mm.; of the female, 27 mm. Length of the pronotum, ♂ 15 mm., ♀ 6½ mm.; of the thorax, ♂ 17 mm., ♀ 15 mm.; of the abdomen, ♂ 15 mm. ♀ 12 mm.; of the ovipositor, 14 mm. Length of the fore tibia, ♂ 9 mm., ♀ 7–8 mm.; hind tibia, ♂ 18 mm., ♀ 15 mm.; of the hind femur, ♂ 21 mm., ♀ 16–17 mm.; width at mesonotum, ♂ 9 mm., ♀ 8 mm.; length of the antennæ, 45 mm.

Collected on Pitt Island and presented to the Christchurch Museum by Mr. J. J. Fougère.

Art. XIV.—*Description of a New Blow-fly from Campbell Island.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Calliphora cockaynei, sp. nov.

♀. Head and face brownish-black, third joint of antennæ lighter; palpi and tip of proboscis fulvous. Eyes hairy; thorax brownish-black; a fulvous spot on each side behind the eye and another at the base of the wings. Wings tinged with fulvous; the veins dark-brown, but fulvous at their insertion, thus making a double fulvous spot on the side of the thorax. Squamæ grey; abdomen metallic greenish-blue; legs black. Length, 12·5 mm.; wings, 10 mm.

Hab. Campbell Island. Collected by Dr. L. Cockayne, July, 1903.

Described from a single specimen which had been put into formalin.

Allied to *C. quadrimaculata*, but easily distinguished by the colour of the abdomen.

Art. XV.—*On the Occurrence of the Curlew-Sandpiper* (Ancylochilus sub-arquatus) *in New Zealand.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

The Curlew-Sandpiper is one of those birds which breed in the Arctic regions and pass the winter in Africa, India, and Australia. We do not know it as a regular visitor to New Zealand, but two specimens were shot at Lake Ellesmere by Mr. Edgar Stead on the 5th of last April, one of which went to the British Museum and the other to the Canterbury Museum. The British Museum specimen is in the winter plumage, but the one in our Museum is just commencing to change into the breeding-plumage, having rufous feathers on its breast and rusty ones on the neck and back. The length of the bill is 1·4 in.; of the wing, 5·3 in.; of the tarsus, 1·15 in.; and of the middle toe and claw, 1·15 in.

The bird is easily recognised from any of the other Sandpipers by its long slender bill, which is slightly curved downwards, and by the white upper tail-coverts.

The winter plumage is as follows: Above ashy-brown, the centres of the feathers darker; rump and upper tail-coverts white; tail ashy-brown, with a subterminal bar of dusky, the feathers with white shafts and fringed with white. Under-surface pure-white, with tiny lines of dusky-brown on the sides of the face, sides of the neck, and lower throat and fore-neck.

Art. XVI.—*On the Anatomy of* Paryphanta fumosa, *Tenison-Woods.*

By R. Murdoch.

[*Read before the Wellington Philosophical Society, 17th December, 1903.*]

Plate VI.

Vitrina fumosa, Ten.-Woods. Proc. Lin. Soc. N.S.W., iii., p. 124, pl. xii., figs. 3, 3*a*.

V. fumosa, Ten.-Woods. Petterd, Monograph, "Land Shells of Tasmania," 1879, p. 51.

To the kindness of Mr. Charles Hedley and Mr. W. F. Petterd I am indebted for an example of this rare species. The specimen under notice was collected and identified by Mr. Petterd, the original discoverer of the species. It was gathered at Mount Farrell, north-west Tasmania, and is certainly one of the rarest members of the genus *Paryphanta*.

The shell (figs. 1 and 2) is subglobose, imperforate, exceedingly thin, shining, of a dark-olive tint, and without sculpture. Whorls 3, rapidly increasing in size. The spire small, lightly convex, and scarcely elevated above the body-whorl. Protoconch consists of about $1\frac{3}{4}$ whorls, lighter in colour and apparently devoid of sculpture. Sutures impressed. The lines of growth on the body-whorl are minute, somewhat irregular, and have a slightly crimped appearance at the suture. Aperture broadly ovate and slightly oblique to the axis of the shell. Columella short, curved, and very lightly expanded. Outer lip slightly projecting at the suture. The umbilical area slightly impressed. Alt., 10 mm.; lat., 13·5 mm.

The shell, with the exception of the apical whorls, appears to consist almost completely of conchin, and in this respect it resembles certain of the New Zealand species—*e.g.*, *P. urnula*, Pfr.

The animal is, unfortunately, very much contracted, hard, and difficult to handle. It is black or blue-black in colour, somewhat lighter posteriorly. The rugæ on the sides of the body and neck are large, irregular in shape, and do not

appear to form regular rows, except some two or three on the neck. Behind the visceral mass there is a median dorsal line which does not extend to the full length of the tail, and the rugæ on this area are considerably smaller than on the anterior portion of the animal. The tentacles are completely retracted, and the labial projections, if any, are not distinguishable. On the external surface of the mantle, and close to its margin, is a lightly impressed line of a dark-blue colour, and on the under-side are small right and left lappets, the latter forming a narrow inconspicuous fold. The foot is of a sepia colour around the margins, shading to lighter in the middle area; except in colour there is no indication of it being divided into median and lateral areas. It is thrown into several transverse prominent folds, and its whole area has the appearance of being minutely transversely and longitudinally grooved. This rugose aspect is doubtless largely due to its contracted condition.

The buccal mass (fig. 3) is large, and very similar to the corresponding organ in other members of the genus; but in the form of attachment of the retractor muscle it differs from any that have come under my notice. The muscle is completely attached to the posterio-ventral side of the buccal mass; it extends from the posterior and forward to the flexure, as shown in the figure. The muscle forms, as it were, a double cushion (fig. 4), attached on the inner margins and anterior areas. In *P. hochstetteri*, Pfr., and *P. busbyi*, Gray, the retractor muscle almost envelops the curved-down posterior end of the buccal mass. It is roughly in the form of a hollow cone, but the greater portion of the muscle certainly goes to the ventral side. In longitudinal section of the buccal mass it is found that the area of greatest muscular concentration is at the ventral flexure or immediately posterior to it. To this area are attached the enormously developed posterio-dorsal series of muscles, which proceed from the odontophoral cartilage and radular sac. It would thus appear that in *fumosa* the retractor muscle is more completely applied to the area where the greatest resistance is required.

The radula has the formula 38–0–38, the rows of teeth forming an obtuse angle curved towards the margins. The teeth (fig. 5) are all aculeate. They increase in length to about the ninth; a few succeeding teeth are apparently without change, thence they very gradually decrease in length; the twenty-fifth to the twenty-seventh diminish somewhat more rapidly, and the last is reduced to about one-half of the length of the adjoining tooth. With the exception of the innermost tooth, all have practically the same diameter; thus the teeth towards the margins, and the centre also, are in proportion to their length more robust than the intermediate teeth.

The œsophagus enters the buccal cavity in the anterior third; it is a thin, narrow tube, without any distinctly marked crop. The stomach forms a small elongated sac surrounded by the liver; and the tract of the intestine is apparently similar to *Helix*.

The salivary gland (fig. 6) partly envelops the œsophagus, and is situate on the posterior portion of the buccal mass; it consists of right and left lobes, the former being somewhat the smaller. The two lobes anteriorly are almost completely fused together; viewed from the ventral side the divisional line is seen to form a well-marked furrow on the posterior half of the gland, but on the anterior portion it is scarcely indicated, and the two parts cannot be separated without severing the tissue of the gland. There is but a single salivary duct, which proceeds from the median cleft on the anterior end of the gland and enters the buccal cavity on the right of the œsophagus and slightly posterior to it. Transverse sections taken at the point where the salivary duct becomes merged in the gland show that the ducts proceeding into the right and lesser lobe are somewhat more conspicuous than those to the left side. Neither of the lobes or glands appears to have suffered any loss of function. In the situation of the salivary duct it has the appearance of having changed from its normal position, and to some extent doubtless it has, but it is presumable that the anterior end of the gland is more perfectly fused and drawn together than in its normal condition; also, it is fairly conclusive proof that in a normal state the glands are functionally united. The condition of the salivary glands in *Paryphanta* is somewhat variable: thus, in *P. hochstetteri* they are functionally united, while in *P. busbyi* they are distinctly separate in function. In the former species the union of the glands is most apparent in the very young individuals. The right gland is much the smaller; its duct divides into two branches, either immediately before or as it enters the substance of the gland. One of these branches proceeds to the anterior portion of the left gland, where it divides into several lesser tubes; also, the cellular structure of glands is continuous in this area. In adult specimens the line of cleavage between the two glands is much more pronounced, but there is always some portion in which the glandular mass is continuous. The left salivary duct unites with its gland in a position considerably posterior to that of the right duct and gland.

The pedal gland (fig. 7) opens anteriorly between the head and foot; it forms a long slender tube much folded and lying upon the floor of the body-cavity. Its posterior end is enlarged, partly imbedded in a shallow cavity in the muscles of the foot, and from its ventral side proceeds a small muscle which unites with the adjoining tissue.

Retractor muscles : The buccal-mass retractor is very large, almost equalling the pedal muscles. Both muscles coalesce towards their posterior extremity. The tentacle-retractors arise in separate bands from the posterior portion of the pedal muscle ; they bifurcate towards their anterior ends and supply the retractors to the inferior tentacles. The right ocular retractor passes between the branches of the genital system. The form and position of the muscles, with the exception of the attachment of the retractor with the buccal mass, agree perfectly with the New Zealand species—*busbyi*,* *urnula*,† and *hochstetteri*.†

Pallial region (fig. 8) : The kidney is tongue-shaped, its anterior end having a somewhat truncated appearance ; in length it is twice its breadth, about half the length of the lung, and about one-third longer than the pericardium. The ureter is a well-marked tube of medium width ; it follows the margin of the kidney, and appears to open into the right posterior corner of the lung close to the rectum.

The pericardium is in the usual position on the left side of the kidney. The great efferent pulmonary vein follows the margin of the ureter to a point almost in line with the right border of the kidney ; thence proceeds forward towards the respiratory pore. There are 3 comparatively large pigmented efferent vessels on the cardiac side of the lung ; also in front of the respiratory pore are several small pigmented vessels from both rectal and cardiac sides. On the rectal area of the lung are numerous small efferent and afferent vessels, but they are not pigmented, and it requires a very careful illumination to show any trace of them. On the cardiac side are several afferent vessels, two of which are comparatively large, and with pigmented margins.

Generative organs (figs. 9 and 10) : The atrium is very short. The penis forms a simple sac of medium length, with the retractor muscle inserted in the posterior end and attached distally to the diaphragm. Its internal wall has a prominent thickening, yellowish in colour and the surface covered with minute granules ; it extends from the entrance of the vas deferens to almost the anterior termination of the penis. The vas deferens arises a little below the apex of the penis ; it has a few slight convolutions, thence a slender uniform tube until immediately before its union with the oviduct, where it is enlarged, almost sac-like. The vagina is somewhat slender, and in length rather more than equals the penis. The receptaculum seminis is in the form of a small elongated sac, situate close to the sacculated uterus, and when the organs

* Trans. N.Z. Inst., vol. xxxv., pp. 258–62, pl. xxvii.
† Proc. Malac. Soc., London, 1903, vol. v., pt. iv., pp. 270–73.

are in a natural position (fig. 9) it is completely enveloped by the sacculations. Its internal walls are richly plicated. The albumen gland very large, and the hermaphrodite duct densely convoluted. The right lobe of the liver, including the hermaphrodite gland, was torn off and remained in the shell when extracting the animal.

The systematic position of *fumosa* has already received some attention. Ancey, in *Journal de Conchology*, xlix., p. 12, places it in *Paryphanta*, and refers to it as an interesting Antarctic species. Suter, in the same publication (p. 316), at once throws doubt on its pertinence to *Paryphanta*. To this Ancey replies (J. de C., li., p. 44) that until anatomical investigation disproves it the species may by shell characters fairly be assumed to be a *Paryphanta*.

The most striking peculiarity in the anatomy of the several known species of *Paryphanta* is the marked difference in their genital organs. The difference is chiefly centred in the receptaculum seminis; the contour of this organ is so distinct in each species that, when added to the minor difference in other organs, it presents a type of genitalia unusually distinct amongst species of the same genus. *P. busbyi* can scarcely be compared with the other members, its genital organs are almost totally different; but this condition is probably due to degeneration. On the other hand, the general anatomy does not appear to present any important differences, except the form of attachment of the buccal-mass retractor in *P. fumosa*. This divergence from the typical form is an important feature, for as a rule the form and position of the principal muscles in a genus or family show a far smaller range of variation than organs such as the jaw, dentition, or genitalia; however, apart from this feature, the arrangement of the muscles, as previously stated, is identical with *P. hochstetteri;* also, there is a mass of evidence from totally diverse, uncorrellated organs which is quite in accord with *Paryphanta*.

EXPLANATION OF PLATE VI.

Paryphanta fumosa, Ten.-Woods.

Fig. 1, 2. Shell.
„ 3. Buccal mass, &c.
„ 4. Buccal-mass retractor muscle, form of attachment.
„ 5. Teeth.
„ 6. Salivary gland, ventral side.
„ 7. Pedal gland.
„ 8. Pallial region.
„ 9, 10. Generative organs.

REFERENCE LETTERS.

af. v. Afferent pulmonary veins.
alb. g. Albumen gland.
ef. v. Efferent pulmonary veins.
h. d. Hermaphrodite duct.
int. Intestine.
rc. Rectum.
k. Kidney.
l. Left salivary gland.
œs. Œsophagus.
p. Penis.
per. Pericardium.
r. Right salivary gland.
r. m. Retractor muscle.
r. s. Receptaculum seminis.
s. d. Salivary duct.
s. g. Salivary gland.
u. Ureter.
v. d. Vas deferens.

ART. XVII.—*On the Occurrence of* Vanessa atalanta *and* Plusia festucæ *in Southland.*

By ALFRED PHILPOTT.

[*Read before the Wellington Philosophical Society, 5th August, 1903.*]

EARLY in April of this year I had an opportunity of examining a collection of *Lepidoptera* formed by Mr. Robert Dunlop, manager of the Orepuki Oil and Shale Works. Among them I was very much surprised to see a specimen each of *V. atalanta* and *P. festucæ*. I learnt from Mr. Dunlop that the specimen of *V. atalanta* was the only one secured out of several seen. This insect, however, has been previously taken in New Zealand. Mr. T. W. Kirk states (Trans. N.Z. Inst., xvi., 550) that he captured a specimen in the Wellington Botanical Gardens in the summer of 1881, and at a subsequent date saw others.

P. festucæ, I believe, has not previously been observed in New Zealand. The specimen under notice was attracted by the electric light, and, though not in the best condition, I do not think there can be any doubt of its identity. Mr. Meyrick says ("Handbook of British Lepidoptera," 157) that *P. festucæ* is found in Britain and Ireland, north and central Europe, and northern Asia. It is just possible that the species is also a true inhabitant of New Zealand, like its near relative *P. chalcites*.

ART. XVIII.—*Notes on Southern* Lepidoptera.

By ALFRED PHILPOTT.

[*Read before the Wellington Philosophical Society, 7th October, 1903.*]

THIS paper is intended as an extension and amplification of my "Catalogue of Southland *Lepidoptera*" (Trans. N.Z. Inst., xxxiii., 167). I have also taken the opportunity to correct several errors which unfortunately appeared in that

article. Though the majority of the species dealt with are to be found in Southland, I have not restricted myself to artificial boundaries, and "southern" in this case must be understood to mean practically Southland and Otago. For much information regarding the moths of central Otago I am indebted to Mr. J. H. Lewis, and I have also freely availed myself of information supplied by other trustworthy workers. Where no locality is given for a species it may be understood that it is to be found in the near neighbourhood of Invercargill.

Metacrias strategica.

This moth appears to be on the increase. The larva is probably distasteful to birds, and as it feeds on introduced grasses its increase is not a matter for surprise. On the 9th December, 1901, I put a couple of newly emerged females in a box and placed it on a low shrub. This was at half-past 5 in the morning, and in a few minutes several males were flying round the bush, and in the course of the day nearly two hundred visited the box. I have several times seen the males on the wing between 5 and 6 a.m. It resembles in this habit the very common *Nyctemera annulata.*

Miselia iota, Hdsn.

A very worn example of this moth was taken in the winter of 1900, and a second was secured at sugar in October, 1901.

Orthosia immunis.

There appears to be only an autumn brood of this moth. I have met with it in fair numbers on the ragwort (*Senecio*) in March, but have not taken it at any other time.

Physetica cærulea.

This moth may be struck off our southern lists for the present, the Orepuki examples having turned out to be *Leucania moderata.*

Leucania propria.

This species is often confused with *L. atristriga.* The fore wings are, however, broader in *propria,* and the difference in form of the dark longitudinal basal streak is very noticeable. This streak in *atristriga* tapers to an acute point, while in *propria* it is but slightly tapered, and ends obtusely.

L. acontistis.

I learn from Mr. J. H. Lewis that this species is common at Ida Valley and Wedderburn.

L. toroneura.

Also fairly common at Ida Valley.

Melanchra disjungens.

On the authority of Mr. Robert Gibb, Tuturau, near Mataura, may be added to the localities for this handsome moth. It is strange that it has never been taken in this district, which is not more than thirty miles from Tuturau.

M. paracausta.

Abundant at Haldane and Tuturau; much scarcer at West Plains.

M. lithias.

Common at Wedderburn, J. H. Lewis.

M. proteastis.

For the past three years I have always obtained a few examples of this rarity during the month of April.

M. diatmeta.

Three in December at flowers of *Parsonsia albiflora*,* and one at sugar in September.

M. umbra, Hdsn.

Recently described by Mr. Hudson from specimens secured in this district. This fine moth, which is common during the summer months, is extremely variable. Three varieties are figured by Mr. Hudson.

M. homoscia.

Rare, but occurring from October to June.

M. grandiosa.

The type specimen was taken at sugar on the 11th May. A few evenings later another was secured by Mr. George Howes.

M. octans.

Evidently a very rare insect. Beside the type specimen, now in Mr. G. V. Hudson's collection, but one other example has been taken. This is in the possession of Mr. Robert Dunlop, of Orepuki,† who secured it at the electric light.

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* I should point out that this plant, though sometimes called the white rata here, is a totally distinct species from the white rata (*Metrosideros*) of the north.

† Mr. Dunlop's address is now Shettleston, Glasgow, Scotland.

M. exquisita.

Type taken at sugar in December. Mr. Lewis has also taken one at Ida Valley.

Agrotis admirationis.

Fairly common at Ida Valley.

Dasypodia selenophora.

This fine moth may, I think, be placed on our list as permanently established. About a dozen examples have been noticed during the last three years.

Tatosoma topea.

Fairly common at flowers of *Parsonsia albiflora* in December.

Paradetis porphyrias.

Mr. G. V. Hudson found this peculiar little moth in fair numbers at Paradise, Lake Wakatipu.

Hydriomena rixata.

Common at light from December to February.

H. purpurifera.

One specimen in January at flowers of ragwort. The species is fairly common on Flagstaff Hill, near Dunedin.

H. subochraria.

One example in February at flowers of ragwort.

Venusia verriculata.

I secured one at sugar in June. A dense fog prevailed, and no other insects were about.

Xanthorhoe orophyla.

Mr. J. H. Lewis has met with *orophyla* at Wedderburn. It is probably generally distributed north of Dunedin.

X. stinaria.

According to Mr. Lewis this species is very common at the Matukituki River, Wanaka.

X. occulta.

Rare, but might easily be passed over as *ægrota*.

X. oraria.

Abundant during the summer months on the sandhills near the coast.

X. cinerearia.

This moth varies considerably in point of size and depth of colouring. I have one specimen so dark as to be almost black.

X. bulbulata.

Common at New River on sandhills, and probably found in most uncultivated open situations.

Lythria euclidiata.

Abundant in all open undisturbed situations.

Dasyuris partheniata.

Mr. George Howes took several near Dunedin.

Notoreas insignis.

I have examples from Wedderburn.

N. synclinalis.

I have not met with this beautiful moth in any other locality than Seaward Moss, where it is very common during the summer months. When on the wing the insect appears to be almost black, the striking coloration of the fore wings not being observable.

Theoxena scissaria.

Ida Valley in October.

Selidosema fenerata.

Not common; one or two at ragwort in February.

S. fascialata.

Fairly common at ragwort in February.

Hybernia indocilis.

Wedderburn, J. H. Lewis.

Sestra flexata.

I have taken so far but one example of this species, and am inclined to regard it as an extreme form of *humeraria*.

Ipana leptomera.

The southern forms of this variable species appear to be darker than those of the north. Examples from Wellington which I have had an opportunity of examining are light ochreous-brown, while southern forms (males) are dark-brown and the females delicate silvery-grey. The male variety with the four black spots on the fore wings is not uncommon here, while the form with the large black blotch in the centre of the fore wings is occasionally met with.

Declana egregia.

Mr. Robert Dunlop, of Orepuki, has taken a fine series of this handsome moth; in fact, he found it to be one of the most frequent visitors to the electric light. It seems to be a constant form in a very variable genus.

D. hermione.

Several at light, Orepuki.

D. griseata.

One at sugar at West Plains, and several at Orepuki. Very variable.

Erebia pluto.

Fairly common on the mountains round Lake Wakatipu.

Erebia butleri.

Humboldt Range. I am indebted to Mr. G. V. Hudson for examples of this and the preceding species.

Chrysophanus salustius.

There is a great difference between northern and southern forms. Typical Wellington males are almost one-quarter larger, and exhibit very little of the dark-brown colour, the spots being reduced to mere dots, and the terminal bands being very narrow. Examples from this district have the brown colouring extending from base to about $\frac{1}{3}$, and broad borders of the same colour on costa, termen, and dorsum; the spots are also large, and in many cases form unbroken bands. Altogether, our variety of *salustius* much more nearly resembles *C. enysii* than Wellington specimens of *salustius*. An apparently constant distinction between *enysii* and *salustius* will be found in the colour of the cilia of the hind wings. In *salustius* this is bright-yellow, in *enysii* dull-orange.

Diptychophora persophanes.

Very common here among manuka during summer. I have also examples from Dunedin and Lake Wanaka.

D. lepidella.

West Plains, Dunedin, and Lake Wanaka. Probably generally distributed wherever manuka (*Leptospermum*) is found.

D. interrupta.

Lake Wanaka and Ida Valley. Mr. Lewis informs me that Ida Valley specimens are duller and more inconspicuous than Lake Wanaka forms.

D. auriscriptella.

Plentiful among manuka. Our variety appears to be somewhat smaller and duller in colour than northern forms.

Thinasotia flaviferella.

Wedderburn.

Crambus simplex.

Common at Wedderburn. I have also met with it at Sandy Point and New River, near Invercargill.

C. apicellus.

Abundant during summer months.

C. vitellus.

Fairly common, West Plains and Wedderburn.

C. tahulalis.

Very rare. One example at light in February.

C. cyclopicus.

Wedderburn.

C. corruptus.

Wedderburn.

C. xanthogrammus.

Ida Valley. I am indebted to Mr. J. H. Lewis for specimens of this and the two preceding species.

C. aethonellus.

Abundant and generally distributed November to January. Some slight variation is exhibited in the form of the white central stripe of the fore wings and the depth of ground-colour.

Orocrambus thymiastes.

This beautiful insect is abundant at Seaward Moss. I have not met with it in any other locality.

Diasemia graminalis.

Very common on sandhills at New River from October to January. It is not restricted, however, to sandy situations, being found in plenty in most open localities.

Paraponyx nitens.

Common at light in February.

Scoparia indistinctalis.

Not common. I have met with two or three specimens.

S. ustimacula.

Fairly common in low-lying bush.

S. trivirgata.

Abundant in dry open country. The markings appear to be constant, but there is unusual variation in point of size.

S. chimeria.

A few examples in bush during February.

S. colpota.

Abundant in swampy bush in January and February.

S. asterisca.

Rare. One or two at light in February.

S. exilis.

Common, and generally distributed.

S. encapna.

During February I found this species in fair numbers in a swampy situation here. It is not easy to follow its movements when on the wing, as its flight is erratic and rapid.

Platyptilia haasti.

P. falcatalis.

The moth referred to as *falcatalis* in the "Catalogue" (Trans. N.Z. Inst., xxxiii., 167) should be *haasti*. I have, however, since found the true *falcatalis* at Waihopai. It appears to be much scarcer than *haasti*.

Pterophorus lycosemus.

Several examples in December.

P. monospilalis.

A few, associated with *lycosemus*. Are they varieties of one species?

Pyrgotis pyramidalis.

Otatara in October. Not so common as *plagiatana*.

Harmologa sisyrana.

H. oblongana.

I am indebted to Mr. Lewis for examples of these insects. They were taken at Wedderburn.

H. amplexana.

Fairly common.

Atomotricha ommatias.

An early spring species. Very common at sugar in April and May.

Brachysara sordida.

Also an early species. Not so common as the preceding.

Trachypepla euryleucota.

A few in December. My specimens were all taken when the manuka (*Leptospermum*) was in blossom. I am inclined to think that as the moth sits at rest its white head, thorax, and basal portion of wings are of protective value by reason of their resemblance to an opening manuka-bud.

Semiocosma peroneanella.

Not common. Generally distributed. Through the kindness of Mr. G. V. Hudson I have been enabled to compare the northern *S. peroneanella* with this insect (*Semiocosma mystis*, of Meyrick) and am unable to separate the species. The character relied on by Mr. Meyrick as distinctive is by no means constant in the southern forms.

S. paraneura.

Common at sugar in December and January.

Gymnobathra calliploca.

Very common in forest during summer.

Œcophora epymilia.

Comes occasionally to sugar in November and December.

Œ. griseata.

I think that this species may be taken off our southern lists for the present. I cannot find that Mr. Howes's examples differ from *hemimochla*.

Phæosaces liochroa.

Uncertain in appearance. I found it in some numbers in the summer of 1901–2.

Heliostibes electrica.

Not uncommon in January.

Erechthias fulguritella.

Occasionally met with.

Gracilaria linearis.

Frequently taken at light, and common among rough herbage during spring and summer.

Lysiphragma howesii (mixochlora).

Not uncommon. Its pupal cocoons may be found in similar situations to those of *epixyla*, but are not so conspicuous, being often almost hidden in the substance of the bark. Mr. Ambrose Quail described this insect as *howesii*, but Mr. E. Meyrick's description of *mixochlora* seems to me to fit it very well, and I have some doubts of its distinctness.

Porina dinodes.

I took about a dozen examples of this handsome moth at light in March, 1902. The larvæ live on the roots of grasses, and inhabit deep tunnels lined with silk. When full-grown they are nearly 4 in. long, and much lighter in colour than the larvæ of *despecta* or *cervinata*, being whitish-ochreous, with paler neutral surface and darker thoracic segments. The head is bright brownish-red. The tunnels are driven in rather an oblique direction to a depth of from 15 in. to 20 in. Three examples which I tried to rear pupated about the middle of August, but failed to emerge from that state. I am strongly of opinion that the larva of this moth is the "vegetable caterpillar." No other moth in this district known to me is large enough to warrant the assumption that its larva may be the host of the fungus. I have several times found the fungus-attacked larvæ here, and, as far as a comparison between these and the living larvæ of *P. dinodes* can be trusted, I think it bears out my opinion.

P. cervinata.

In November, 1900, I was successful in taking for the first time females of this species. They are very rare in comparison with the males, and are duller in colour, with fewer markings.

Art. XIX.—*Notes on an Insect found in some Hot Springs at Taupo.*

By J. W. Poynton.

[*Read before the Wellington Philosophical Society, 2nd September, 1903.*]

About a mile from Lake Taupo, close to the Taupo–Napier Road, are the well-known hot springs locally named the "Black Terraces," from the terrace-formations of dark colour formed by the principal springs.

The terraces are of the usual kind. There is a pool of water confined by a rim of siliceous deposit. The hot water flows over this rim at the lowest part and falls into another basin below. There are perhaps a dozen of these small

cascades from the source of the largest springs to the bottom where its waters flow into the creek. As the water spreads out in several directions after issuing from the earth there are different series of these basins, and altogether they would cover about a quarter of an acre. Where there is water on the rims it is quite shallow, but a considerable part of most of them is exposed. A few inches from the edge the water deepens to 6 in. or 8 in. Covering the bottoms of these pools or basins, which vary in area from less than a square foot to several square yards, there is a slimy vegetable growth of dark-green colour of varying thickness.

While on a visit to these springs last March I noticed great numbers of small flies hovering about the pools or on the silica at their edges. They were really in millions, some of the dry patches of silica being covered by them to a depth of an inch or more. Their size was about half that of the common house-fly. In shape they were something similar, but more slender and graceful, and of a dark colour, almost black.

Their power of flight was feeble. I asked a resident of the locality if they appeared in the autumn only, but he assured me that they were there all the year, and that in the spring-time numbers of native birds gathered about the springs to feed upon them.

It occurred to me that they might breed in the hot water, and so I examined the organic matter at the bottom of the basins. It was alive with larvæ about one-half as large as that of the blow-fly, of a dark greyish-green colour, shaped curiously like a shark with its double-lobed tail. In still pools this slime could be seen all in motion, so numerous were these larvæ. The green matter was evidently their food, and supported them generously, judging by their numbers. On the surface of the water a great many pupa-shells were floating. These shells drifted to the lips of the basins, and in a great many places, becoming entangled, they formed small obstructions across the little depressions through which the water flowed. As silication proceeds rapidly in most of these springs, it is obvious that these rafts of shells, being cemented together and to the basin-edges by the silica, will in time raise the level of the water, compelling it to find an exit elsewhere, and this in turn will get blocked too. This may afford an explanation of the remarkably level nature of the walls of these small reservoirs. I broke off a piece of the top of one of these dams, and the outlines of numerous shells imbedded in the silica were clearly visible.

I regret very much that my visit, which was limited to about an hour, prevented me from making further observations. Some specimens of the fly were sent by Mr. Hudson

to Captain Hutton, who said it was an undescribed species of *Opomyza*.

Some very interesting questions are presented for solution by this little creature: Has it any enemies in the hot water where it develops? If not, it is not surprising that in its mature form it appears in such numbers all the year round. Has it by long residence in the hot water changed its nature, so that it no longer breeds at certain times of the year? Where food is abundant, and the temperature of the water is practically the same the year through, there would be no necessity for a breeding season. If the nature and habits of the insect have been much changed from those of its nearest relatives, these facts may indicate a longer period of existence for our thermal springs than they are generally credited with.

The statement as to the gathering of the birds might also be investigated. There is no natural bush of any extent within miles of these springs, and the congregation at a particular time of the year of many native birds may be due to a survival of an ancestral habit, as some avian migrations are known to be.

It is a curious thing that the cast-off shells should materially assist in building these natural incubators, as I am certain they do. Complete sections of different basin-walls should be made in order to ascertain if this process has been in operation since the beginning of the terrace-formation.

These questions are deserving of further study by a competent scientist.

Art. XX.—*The Sipunculids of New Zealand.*

By W. B. Benham, D.Sc., M.A., F.Z.S., Cor. M.R.S. Tasm., Professor of Biology, University of Otago.

[*Read before the Otago Institute, 3rd December, 1903.*]

Plate VII.

Up to the present time only three species of sipunculids have been recorded from our shores, and these were described a good many years ago, before it was customary to seek for generic and specific characters in internal anatomical features; in other words, the external form, colour, and dimensions were considered to yield sufficient material for diagnosis. It will not be surprising, therefore, if a re-examination of these species may necessitate their removal to genera other than those to which they were originally assigned.

The first sipunculid to be described was named *Sipunculus æneus* by Baird* in 1868. Eleven years later Captain Hutton† described two new species, which he named *Sipunculus lutulentus* and *Phascolosoma annulatum*. The former was obtained at Cape Campbell, at the north-east point of the South Island, the latter from Dunedin and Cape Campbell.

My attention was directed to the group by the gradual accumulation of specimens from various parts of the coasts of both Islands, and on dissecting a worm which agrees in external appearance with Captain Hutton's diagnosis of *Phascolosoma annulatum* I at once observed that it possesses internal characters that range it with quite a distinct genus—viz., *Physcosoma* (or *Phymosoma*, as it has been called up to within the last few years). This led me to examine those specimens in the store-room that retain labels in Captain Hutton's handwriting, with the result detailed below.

I find three such bottles or tubes, each containing a single specimen—namely, (*a*) labelled "*Phascolosoma annulatum*, Hutton, Dunedin"; (*b*) labelled merely "Cape Campbell," containing a worm differing entirely from the preceding; (*c*) with a label the writing on which is almost obliterated, but which appears to be "*Sipunculus cyaneus*," without any indication of locality. This specimen appears to have dried up at some time: it is hard, shrivelled, nearly black, and quite unrecognisable. I failed, unfortunately, to find any trace of tube or bottle bearing a label "*Sipunculus lutulentus*," either in the store or in the Museum itself. It is possible that it was sent, together with a collection of annelids, to the British Museum by the late Professor Parker. The tubes (*a*) and (*b*) are either Hutton's "types" or "cotypes." The worm contained in the former (*a*) is not *Phascolosoma* at all, but is *Physcosoma*, characterized by the crescentic form of the tentacular crown situated above the mouth, and by the longitudinal muscles being in several distinct bundles; that in (*b*) belongs to the interesting genus *Dendrostoma*, as is shown by the form and arrangement of the circumoral tentacular crown.

Physcosoma, Selenka, 1897 (= *Phymosoma*, auctorum).

Physcosoma annulatum, Hutton = (*Phascolosoma annulatum*, Hutton.)

As the specimen in the tube agrees almost precisely with Hutton's diagnosis I insert it here. In the original diagnosis, however, there are one or two slight errors, due probably to the examination of specimens imperfectly extended.

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* Proc. Zool. Soc., 1868, p. 81.
† Trans. N.Z. Inst., xii., p. 278.

These I have corrected, and the corrections are indicated by italics:—

"Body papillose, cylindrical, tapers posteriorly; pale-brown, tubercles darker. Proboscis nearly as long as the body, and tapering gradually into it; posteriorly papillose, and coloured like the body; anteriorly smooth, *very pale, frequently* with some brown blotches; the anterior end encircled by about *18 to 20* narrow brown raised rings *of hooklets*. Mouth with a *dorsal crescent* of *about 20* short blunt oral tentacles."

Localities.—I have received specimens of this worm from the following localities, and in considerable numbers from some of these localities, viz.:—Stewart Island: Collected by the late Professor Parker, by Messrs. H. Suter, W. M. Thomson, and E. Jennings. Foveaux Strait: From the oyster-beds, collected by Mr. A. Hamilton. Warrington: Collected by myself. Dunedin: Collected by Captain Hutton. Specimens from each lot have been dissected, as well as the "cotype." They all agree in essential characters, of which a detailed account follows:—

Form of Body.—For descriptive purposes it is convenient to distinguish the body from the proboscis (or introvert), for the latter may be retracted within the former, unless the animal be carefully anæsthetised.

(*a.*) The *body* is, as usual, cylindrical, and pointed more or less markedly at its posterior end. It is widest in the middle, and somewhat tapered towards the base of the introvert. Usually the body is curved to one side, so that the ventral surface is concave. But if a series of specimens be studied this form is departed from in various degrees, owing partly to the different methods of preservation and partly to the different states of contraction of circular and longitudinal muscles at death. Now, as in times past stress has been laid on the form of the body in diagnosing species, it is worth noting one or two of the forms assumed owing to the above cause: The hinder moiety may be more strongly contracted than the anterior moiety, so that the posterior end looks somewhat like a tail; or the circular muscles at both ends may be more strongly contracted than those of the greater part of the body, and a more or less spherical form results; while at other times the middle of the body is constricted. (See figures.)

(*b.*) The cylindrical *proboscis*, or introvert, when fully extended is much narrower, and usually as long as or even longer, than the body; but necessarily the proportions vary somewhat according to the condition at death.

The tentacles are twenty in number, short, finger-shaped, and grooved along their outer—*i.e.*, oral—margin. They are arranged in the manner typical of the genus in a crescent

immediately above the mouth, with the concavity directed dorsally. In this dorsal gap are 4 black eye-spots; and occupying the intra-tentacular area is a somewhat rectangular disc, slightly lobed right and left to form 2 small rounded projections, which are only visible on extreme extension. As in some other species, such as *P. varians*, there is a post-oral collar, but it is very small in the present species.

Immediately below the mouth there are several circles of closely set hooklets, each circle having the appearance of a brown narrow ring. The number of these rings varies a good deal: Hutton gives 12 as the number, but in some I count 16 or 18, while in others, when mounted for microscopical examination, there are as many as 20—to which must be added some 5 or more very closely set rings at the oral end of the series, which are not recognisable except under a high-magnifying lens. The individual hooklets are much curved, as shown in the figure.

Colour.—The colour is highly variable; it is generally pale to dark brown, gradually becoming darker at each end. In some of the very pale specimens there are large blotches of very dark pigment, irregular in size and arrangement; but the ground-colour is always very pale—indeed, it appears white in preserved material—and the brown colour is due to pigment in the dermal papillæ which cover the body.

These papillæ are largest and most densely packed at either end, slightly larger—at any rate, in some individuals—at the anterior than at the posterior end, but along the entire ventral surface they are small; and both dorsally and laterally in the middle region of the body they are also quite small. These smaller papillæ have less pigment in them than the larger, so that this middle region is of a paler tint, for the papillæ are here more widely separated from one another, and allow a greater amount of ground-colour to come into view. The papillæ are of the usual circular form.

The anus is, generally, quite inconspicuous, but in some specimens it forms a slight prominence; and occasionally it appears as a paler spot in the dark-brown surroundings.

The colour of the introvert is usually paler than that of the body—sometimes, indeed, it is almost white—and in these cases it is often marked with dark-brown blotches, which are larger near the oral extremity. But the colour at the proximal region graduates into that of the body, and except in this portion, where the papillæ graduate into those of the anterior end of the body, the papillæ are quite minute and invisible without a lens.

Dimensions.—There is a considerable range in the size of the body of my specimens—from 20 mm. to 40 mm.—though an average specimen is about 30 mm. to 35 mm. The "type"

is smaller than several others, though I have several that are still smaller. The introvert is of about the same length as the body, though in some instances it is considerably longer. In one case, mentioned below, the introvert is almost twice the length of the body. This was killed slowly by adding KCN to the water; so that the total length of a fully extended (preserved) individual is 50 mm. to 70 mm.

Dimensions in Millimetres.

—	Type.	Warrington. (Fig.)	Stewart Island.		Foveaux Strait.	
			(*a.*)	(*b.*)	(*a.*)	(*b.*)
Length of body ..	20	30	39	33	32	22
Greatest diameter of body	4	9	8	8	6	6
Length of introvert ..	*	30	†	†	15	40
Diameter of introvert	2	2	3	2·5	2·5	2

* Only 5 mm. of introvert is everted.
† Introvert totally retracted.

As to the *internal anatomy* a few words will suffice. The longitudinal muscles of the body-wall are separated into about 18 to 20 major and a few minor bundles. These, as in other species, anastomose, so that the actual number will vary according to the level of the trans-section.

There are four retractor muscles of the introvert, of which two are much stouter than the other two—from two to three times stouter. All are attached to the ventral side of the body-wall a little beyond the middle of the body-length, and the stouter ones are attached somewhat further back than the other two, almost in the same longitudinal line.

The intestine presents 7 or 8 double coils—*i.e.*, the descending and ascending limbs each turn 7 or 8 times round the axis of the spire. There is a spindle muscle present, which is attached posteriorly as well as anteriorly. In addition a slender muscle passes from the anterior end of the intestinal coil, to be attached to the body-wall close to the nerve-cord. A similar muscle is mentioned by Shipley as present in *P. varians*.*

There are two "brown tubes" (nephridia). These are comparatively long, nearly half the body-length. Each is, of course, quite free, and is dilated anteriorly to form a nearly spherical bladder, which opens outwards. In some instances this is so greatly distended as to appear like a cæcum.†

* Q.J.M.Sc., xxxi., p. 10.

† An interesting variety of *Physcosoma annulatum* has 3 brown tubes at the same level; but what is most misleading is the presence, at the

Some of the individuals are males, others are females, but I could detect no difference in size or colour between the sexes.

Dendrostoma, Grube (em. Keferstein).

D. æneum, Baird (= *Sipunculus æneus,* Baird, 1868 = *Sipunculus lutulentus,* Hutton, 1879 = *Phascolosoma huttoni,* Benham, 1903). (Index F.N.Z.)

In the tube (*b*) above mentioned is a single sipunculid, which, except in its smaller size, closely agrees with Hutton's diagnosis of *Sipunculus lutulentus;* and, moreover, was collected at Cape Campbell, the locality ascribed to that species. To this matter I will return after describing the worm; for, in addition to this individual, I have received a considerable number of specimens from Auckland and the neighbouring coast. Several of these, as well as the above individual, have been opened.

Form.—(*a.*) The cylindrical *body* is broader posteriorly than anteriorly, but the hinder extremity is bluntly rounded. There is no definite "pyriform swelling," such as Captain Hutton describes for his *S. lutulentus,* in any of my specimens, and in the above-mentioned individual (*b*) the hinder end is retracted, so that it is even more rounded, more obtuse, than usual; and a similar condition is presented by some others in which the introvert is retracted.

(*b.*) The *introvert* is quite short, barrel-shaped, so that its middle is of greater diameter than the anterior extremity of the body. The mouth is surrounded by a four-lobed tentacular crown, the base of which is surrounded by a collar, rendered conspicuous by its deeper purple margin. Each lobe of the tentacular crown is usually dichotomously divided twice successively, so that there are in all 16 short lobules. (There is some variation in actual details, for sometimes only one dichotomy exists; in other cases each lobe ends in 5 or 6 lobules.) Each lobule is fringed on each side by a single row of finger-shaped tentacles or cirri, of which the proximal ones are much larger than the distal ones, there being a gradual diminution in size. There are usually 5 tentacles on each side of a lobule, together with a terminal small one, though I note that often there are only 4 on the inner margin of

hinder end of the body, of a white cap-shaped mass of calcareous material, which, associated with a circular white patch at the base of the introvert, led me, on inspection, to refer it to the genus *Aspidosiphon,* and as such I included it, most unfortunately, in the Index Faunæ N.Z. On closer examination, however, it turned out that the circular patch is situated on the ventral side instead of on the dorsal side, and it is readily scraped away, consisting apparently of some sort of secretion; while the posterior cap consists of a mass of tri-radiant calcareous sponge-spicules, closely aggregated together, and adhering quite firmly to the body-wall.

a lobule and 5 on the outer; thus there are about 160 to 176 tentacles altogether. Each tentacle is grooved on its upper—*i.e.*, oral—face. These grooves lead into a furrow running down the lobule; the latter leads to a similar furrow on the lobe; thence a furrow passes across the oral disc to the subcentral mouth, which is transversely disposed. The structure of this tentacular crown appears to relegate the worm to the genus *Dendrostoma* as defined by Selenka* and by Shipley,† and the internal anatomy agrees with this diagnosis.

Colour.—The colour of the preserved specimens is a very pale yellowish-brown, and has a shiny appearance. The posterior end in some individuals is more definitely brown, while in other cases there is a well-marked dark ring round the base of the introvert. Some individuals are nearly white. Fortunately, I have a note as to the colour and appearance of the living worms collected at Warrington. They are white and smooth to the naked eye. Some are slightly brownish. One individual has white tentacles; in another these are reddish-brown; and Dr. Agnes Kelly, who collected a number of specimens at Waiheke, has noted that they are "yellowish-grey"; and in alcohol they have a more decidedly yellow tint than those collected by me.

The surface of the body is almost smooth in the preserved specimens; but posteriorly there are longitudinal and circular furrows which mark out irregular rectangular areas. These are distinctly visible in some individuals over the hinder third of the body, becoming more distinct as the extremity is approached. These rugosities appear again towards the base of the introvert. In Hutton's specimen (*b*), and in some individuals variously preserved, these furrows are much less evident than in others, so that the body appears in these cases much smoother and more shiny. Thus, in the Warrington specimens a hand-lens is required in order to see these very shallow circular furrows, whereas in some well-preserved individuals from Rangitoto and from Auckland they are very much more distinct, and the "raised areas" render the body rough-looking, especially posteriorly.

There appear to be no papillæ, but under a hand-lens minute black dots are recognisable sparsely scattered over the body, which are probably minute papillæ.

The introvert itself is smooth, paler in colour than the body, and is provided with 3 or 4 irregular circles of widely spaced blunt hooks, which are nearer together on the dorsal than on the ventral side. These circles of hooks occupy about the middle third of the introvert, the anterior margin of which is deeply pigmented, and forms a prominent collar.

* "Challenger" Reports, vol. xiii., pt. 36 (Sipunculidæ), p. 14.
† "Cambridge Natural History," p. 425.

The tentacles are, in the specimens studied, pale—no doubt white in life—but the furrows in the oral disc and the lobes, &c., are purplish; and in one individual examined each tentacle is marked with one or two linear dots of the same colour.

Dimensions.—The average size of the body is about 25 mm., but it varies considerably. The specimen from Auckland has fully extended introvert and tentacles, as will be seen from the following table:—

DIMENSIONS IN MILLIMETRES.

—	Auckland.	Rangitoto.	Warrington.			Cape Campbell.
			(*a.*)	(*b.*)	(*c.*)	
Length of body	30	26	22	18	15	32
Greatest diameter of body ..	6	9	8	8	11	8
Diameter anteriorly ..	3	4	..	..	..	3
Length of introvert ..	10	..	..	..	..	..
Greatest diameter of introvert	5	..	..	..	..	..

Specimen (*c*) is thus nearly spherical.

while several from Waiheke are much smaller than any of these. This difference in many cases is due to differences in condition of preservation.

Internal Anatomy.—The longitudinal muscles form a continuous sheath. There are two large retractor muscles to the introvert, which are inserted into the body rather far back—at about one-third from the hinder end. The spiral intestine exhibits about 8 double coils. The spindle muscle is attached anteriorly only, so that the intestinal spire is free posteriorly.

The vascular system is provided with numerous cæca, resembling the figures given by Shipley for *Physcosoma weldonii*.* There is a pair of free "brown tubes," each of which is dilated spherically at the external aperture; and there is no forward cæcum. Several of the worms examined are sexually mature.

Localities. — Cape Campbell, South Island: Hutton's specimen (*b*). Auckland: Collected by Professor A. P. Thomas and Mr. H. Suter. Rangitoto, in Auckland Harbour: Collected by Mr. H. Suter. Waiheke, in Auckland Harbour: Collected by Dr. Agnes Kelly. Warrington, South Island: Collected by W. B. Benham.

REMARKS.

The scanty literature at my disposal does not permit me to make comparisons with other species of sipunculids, or,

* Q.J.M.Sc., 1891.

indeed, to affirm with certainty that these two species are endemic, but in all probability this is the case. It is interesting to note that, whereas all the sipunculids collected on the North Island are *Dendrostoma æneum*, the commonest species on the shore of the South Island is *Physcosoma annulatum*, and this is the only sipunculid hitherto collected at Stewart Island. Shipley* says that *Physcosoma* "is almost entirely tropical," and that *Dendrostoma* is "found only in tropical seas." The local distribution of these two species along our coasts is, then, of interest in breaking this record. The shores of Stewart Island cannot be termed in any sense "tropical"; and although Auckland Harbour may deserve the epithet, yet Warrington is distinctly extra-tropical, and at this spot I collected, on the same day and under neighbouring stones, both the above-named species.

We have here, then, in the case of *Dendrostoma*, as it seems, a migrant from tropical seas, and further collections along the coast will be examined with increased interest, in the endeavour to ascertain how far north *Physcosoma* journeys, and how far south *Dendrostoma*. Captain Hutton gives "Cape Campbell and Dunedin" as two localities for *Physcosoma annulatum*, so that the two species overlap on the east coast of the South Island.

As to the Probable Identity of Sipunculus lutulentus and S. æneus.

A careful comparison of my numerous individuals with Hutton's specimen (*b*) from Cape Campbell shows a complete identity; and, moreover, with the exception of the greater length ascribed by him to *S. lutulentus*, my specimens and his specimen (*b*) agree with his diagnosis of that species, for the form of the body, which he states ends in a "pyriform swelling," is, as we now know, merely a matter of preservation, due to a constriction of the circular muscles near the hinder end.

Hutton's type of *S. lutulentus* measured 6 in.—*i.e.*, 150 mm.—whereas the largest specimen seen by me is only 40 mm. His measurements, converted into millimetres, stand thus as compared with a fully extended specimen from Auckland presented to the Museum by Professor A. P. Thomas:—

	F. W. H.	A. P. T.
Total length ...	... 150	40
Breadth	... 10	6
Length of introvert...	... 18·75	10
Breadth of introvert	... 6·25	3

* "Cambridge Natural History."

Or, taking the proportional breadths and lengths, we have—

	F. W. H.	A. P. T.
$\frac{\text{Length of introvert}}{\text{Length of body}}$ ...	$\frac{1}{8}$	$\frac{1}{3}$
$\frac{\text{Breadth}}{\text{Length}}$ of body	$\frac{1}{15}$	$\frac{1}{5}$
$\frac{\text{Breadth}}{\text{Length}}$ of introvert ...	$\frac{1}{3}$	$\frac{1}{3}$

I am not aware how far the proportional lengths of body and proboscis are of value in determining specific characters, but, seeing that in *Physcosoma annulatum* there is considerable variation in relative length of introvert and body, depending on the method of killing and so forth (see above), it is probable that the differences above tabulated may be explicable in the same way.

It will be noted that in the Auckland specimen the introvert is relatively nearly thrice as long as in the Cape Campbell specimen, and the question suggests itself, Was the introvert in the latter fully extended? No mention is made of the tentacular crown by Captain Hutton, and it is possible that the introvert was only partially everted. But the animal is relatively about one-third the diameter of the carefully killed individual from Auckland, which might be the result of killing it in strong alcohol.

We have, at any rate, I think, only a difference of size to contend with; and, failing other known differences, it is scarcely likely that this would be a specific difference, as amongst my material the individuals (some twenty or thirty) from Waiheke are much smaller than the Auckland or Warrington individuals.

As I have said, I can find no trace of the undoubted "type" of *Sipunculus lutulentus*, and in communicating with Captain Hutton on the subject he says that, as far as he remembers, he had only one specimen of *S. lutulentus*. If that is so, then the individual (*b*) must be the type, and *Dendrostoma huttoni* be replaced by *D. lutulentum* of the Index F.N.Z.

But now let us turn to Baird's description of *Sipunculus æneus* and compare it with Hutton's description of *S. lutulentus*, and I think we shall find that these two are synonymous. For ready comparison I will arrange the characters in parallel columns: first, Hutton's diagnosis of his species; secondly, Hutton's translation* of Baird's Latin diagnosis; and, thirdly, Baird's longer description, which is here dissected.

* Trans. N.Z. Inst., xi., 316.

S. lutulentus.	*S. æneus.*	
	Hutton's Translation.	Baird's Description.
Colour pale-brown.	Colour white shining-bronze.*	The general colour is white, except towards the caudal extremity, where it is very shining, with an iridescent metallic lustre.
Body cylindrical, narrowed posteriorly, and ending in a pyriform swelling.	Body cylindrical, slender anteriorly, posteriorly thicker, fusiform, reticulated.	The upper extremity is narrow, the body gradually enlarging in size as it descends, so that at the caudal extremity it is three times as large as anteriorly, and is of a fusiform conoidal form, the warty tubercles at the same time being larger there than elsewhere. Scattered over the surface we see a good many *small warty-looking tubercles.*†
Cylindrical portion of the body *smooth*, faintly reticulated anteriorly, but only transversely striated posteriorly; the *posterior pyriform portion rougher, especially the caudal apex.*†	In the anterior portion corrugated, then smoother and *minutely granulated;* caudal apex oval, *smooth, shining.*†	The body is slender, ringed, the rings or annulations being very close together, small and finely but distinctly reticulated across. The upper extremity is strongly corrugately reticulate, the middle portion less distinctly so, and the caudal *almost smooth.*†
Proboscis short, *roughened*, thinner than the body.†	Proboscis short, *smooth*, the anterior portion thicker than the body.†	The proboscis is smooth-looking, but when examined with a glass we see it ringed or annulated or finely reticulated. The proboscis in this species is much‡ thicker than the upper or anterior part of the body.
Length, 6in.; length of proboscis, $\frac{3}{4}$in.; breadth of body anteriorly, 0·4in.; breadth of proboscis, 0·25 in.	Length, 6$\frac{1}{4}$in.; length of proboscis, 6 lines = $\frac{1}{2}$ in.; breadth, anterior end of body, 1$\frac{1}{2}$ lines = 0·12 in.; breadth, posterior body, 4 lines = 0·3in.; proboscis, 2 lines = 0·16 in.	

* An erroneous translation of "*æneo luteus.*"

† The italics in these columns are mine.

‡ His measurements do not show any excessive difference, there being a difference of only $\frac{1}{2}$ line. Baird states that the "oral cirri are not visible," so the proboscis was not fully everted.

It will be noted that the most striking difference in regard to the dimensions of these two species is exhibited by the "breadth of body anteriorly," for in Baird's example this is very much less than in Hutton's. But, presumably, each took the *greatest* diameter, which in the former case is near the hinder and in the latter near the anterior end, and this greatest diameter is nearly identical. May we explain this difference in form by difference of contraction on death?

A comparison of the brief diagnosis of *Sipunculus æneus* with that of *S. lutulentus* presents only three apparent differences, apart from colour and dimensions — viz., the character of the surface of the body in the various regions: (*a*) the condition of the hinder end of the body; (*b*) the condition of the proboscis; and (*c*) the character of the skin of the body. In both the first two cases *S. lutulentus* is "rougher" than *S. æneus*. But if we read Baird's longer description we find that the "smoothness" referred to in the Latin diagnosis is qualified: the caudal extremity being "almost smooth," and the proboscis "smooth-looking." Now, as I have mentioned in the description of the species, I find a good deal of difference exhibited by the surface of the body of the specimens in my possession, depending on the mode of preservation. For example, in two of the Warrington individuals (killed slowly in alcohol) the reticulation—*i.e.*, "roughness"—on the hinder end is by no means evident, and one would call it "smooth"; also, in most of the individuals collected in Auckland Harbour, at Waiheke (preserved in formol), the body appears smooth, whereas in others the body-wall is more strongly contracted and the reticulations are more prominent. (*c*.) Baird's species is said to be covered with "small warty-looking tubercles," or, in the words of the diagnosis, the surface is, in the middle part of the body, "minutely granulated"; whereas *S. lutulentus*, according to Captain Hutton, has a "smooth" body. In the account given of the specimens described in this paper I have mentioned the minute tubercles, and I find that in some individuals these are much less evident than in others, and no doubt this is due to the method of preservation.

As regards the colour, Baird's is "white," Hutton's is "pale-brown." Here, too, I find the same differences, as I have mentioned.

In conclusion, I believe that these two species are synonymous; and, notwithstanding the great difference in size between these on the one hand and the numerous individuals in my possession on the other, I believe that the latter too are of the same species, which must stand as *Dendrostoma æneum*, Baird.

Unfortunately, in preparing my list of worms for the Index F.N.Z. I had not had time to fully examine the character of the tentacular crown, or to compare my specimens with what appears, from Captain Hutton's information, to be the type of his *Sipunculus lutulentus*, so that this sipunculid appears as *Phascolosoma huttoni*.

EXPLANATION OF PLATE VII.

Figs. 1–10 represent *Physcosoma annulatum*.

Figs. 11–14 represent *Dendrostoma æneum*.

Fig. 1. *Physcosoma* (natural size) with the introvert retracted. This is the usual condition in which the animal dies—the position of rest.

Fig. 2. A small individual with the introvert fully extended (natural size). The distal extremity of the introvert, seen from in front.

Fig. 3. Showing the tentacular crescent overhanging the mouth (enlarged), with the brain above.

Fig. 4. The distal extremity of introvert from the side (enlarged), showing the rings of hooklets.

Fig. 5. A hooklet (much enlarged).

Figs. 6, 7, 8, 9 illustrate the different forms (natural size) of body assumed on death, and may to some extent be regarded as various phases of movement during life. In fig. 6 the muscles at the hinder end are strongly contracted and the introvert is nearly fully everted. In fig. 7 the circular muscles in the middle of the body and the introvert are retracted; while in fig. 8 the longitudinal muscles are in contraction, giving rise to a more or less globular form of body. In fig. 9 the body has a normal shape, of moderate extension, and the introvert is almost completely everted. Figs. 6, 7, 9 represent individuals killed slowly by adding alcohol gradually to sea-water; while fig. 7 is a specimen killed suddenly by being plunged into alcohol.

Fig. 10. A specimen with a calcareous cup at the posterior end of body (see next), giving it the appearance of *Aspidosiphon*.

Fig. 11. *Dendrostoma æneum* of the natural size.

Fig. 12. View of the oral disc and tentacular crown (enlarged). This is so far diagrammatic that on the right side some of the tentacles are represented as spread out flat.

Fig. 13. Side view (enlarged) of part of the tentacular crown, showing the 2 lobes, each subdivided into lobules, bearing filiform tentacles.

Fig. 14. A horny spine from the introvert (much enlarged).

Lettering.

br. Dorsal region of head, containing brain, above which are seen the eye-spots.
c. Collar.
h. Rings of hooklets.
i. Introvert.
i^1. Base of introvert.
m. Mouth.
p. Papilla.
s. Spine.
t. Tentacles.

Art. XXI. — *On a New Species of Leech* (Hirudo antipodum) *recently discovered in New Zealand.*

By Professor W. B. Benham, D.Sc., M.A., F.Z.S., Cor. M.R.S. Tasm.

[*Read before the Otago Institute, 9th June, 1903.*]

Plate VIII.

Three years ago Professor Dendy, in association with one of his pupils at Canterbury College, published* a description of a small aquatic leech (*Glossiphonia novæ-zealandiæ*) collected in Lake Takapuna. This is the first certain record of the occurrence of a member of the class *Hirudinea* in this country.

Nevertheless, from time to time people have referred to "leeches" as occurring in various parts of the bush or in lakes—as, for instance, Reischek,† in his interesting account of his ornithological expeditions, mentions being bitten by leeches; and I have heard, in correspondence, of their occurrence. And Dr. Chilton some years ago took Home specimens caught at Lake Hayes, near Queenstown, and gave them to Mr. F. E. Beddard, but nothing has since been heard of them.

Moreover, in the United States National Museum there are two individuals of a terrestrial leech, *Geobdella limbata*, ascribed to "New Zealand."‡ It is very doubtful whether this locality is the correct one. Mr. Moore, who identifies them with the species originally described by Grube under the name *H. (Chtonobdella) limbata*, and found at Sydney,§ writes to me that no information is forthcoming beyond the writing on the bottle (or tube), "New Zealand." Now, it seems to me extremely unlikely that land-leeches, if they occur in New Zealand, would have been overlooked by the various collectors and naturalists who have contributed so much to our knowledge of the natural history of New Zealand during the last few years, and that yet they should have been obtained during a short visit to this colony by the United States Exploring Expedition of 1853. Mr. Moore promises me that he will look through the records of this Expedition and endeavour to find out any details as to these leeches. If they are really from New Zealand, it is probable that they do not belong to

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* Dendy and Olliver, Trans. N.Z. Inst., xxxiii., 1900, p. 99.
† Reischek, Trans. N.Z. Inst., xvii., p. 197.
‡ Moore, Proc. U.S. Nat. Mus., xxi., 563.
§ Grube, "Anneliden in Reise Fregatte 'Novara,'" 1868, p. 41.

the species above mentioned; but more probably they were not obtained from these Islands.*

In view, therefore, of the very scanty information as to this group of animals in our Islands, it was with very great interest that I received from Mr. L. Cockayne, of Christchurch, seven specimens of a leech of considerable size which had been collected by Mr. Dunlop, late of Orepuki, during a botanical and zoological excursion made by these gentlemen to Open Bay Island, off the west coast of the South Island.

These leeches were discovered in a way that suggests why it is that these animals have not been hitherto discovered by collectors. It appears that Mr. Dunlop was searching for insects known as "wetas" under soft tussock-grass in the burrows formed by "mutton-birds" (*Puffinus* sp.). The burrows were in quite moist earth on a hillside, and while plucking up the tufts of grass and groping amongst the roots, which were imbedded in swampy soil, he felt a bite on his wrist. Fortunately, Mr. Dunlop is keenly interested in natural history, and he carefully withdrew his hand and found a leech attached thereto. He proceeded to examine the nest further, with the result that he found six more individuals and some cocoons.

From this account, given to me verbally by Mr. Dunlop, I imagined that we had to do with a land-leech, but examination of the specimens shows that it belongs to an aquatic genus—at any rate, a genus all the species of which, hitherto described, live in water or marshy places—viz., *Hirudo*. I was certainly scarcely prepared to find this widely spread genus in New Zealand. It is to it that the medicinal leech of Europe and Japan and elsewhere belongs, and one would

* Since writing this article I have received a letter from Mr. Moore, dated 19th November, 1903, as follows:—

"Since returning to Philadelphia I have re-examined the land-leeches attributed to New Zealand, and find that my former identification is correct, so far as one can be certain from comparison with Grube's descriptions and figures alone.

"I have traced all clues known to me which might throw light on the authenticity of the label. No one recognises the handwriting, and no trace can be found of the few notes on annelids made by Professor Dana while on the Wilkes Expedition; nor is there any mention in the narrative or reports of the Expedition of any land-leeches encountered either in Australia or New Zealand. The notes were at one time in the possession of [a gentleman] who, so Professor Verrill informs me, became insane as the result of a sunstroke during the Civil War, and has been confined for many years in an asylum.

"As I understand that errors in locality were frequent on the labels accompanying the Wilkes collections, and considering all the circumstances, it seems probable that the specimens were collected at Sydney, one of the stopping-places of the Expedition. In any event, I now consider them as valueless in establishing the occurrence of the species in New Zealand.—Very truly yours, "J. Percy Moore."

have expected that a new genus would represent it here. It is possible, as I indicate below, that a new genus should be formed for it, but in the absence of the necessary time I must leave the more detailed examination of internal characters till a future occasion. At present I discuss only the external features, all of which agree precisely with those enumerated by Professor Whitman* as being characteristic of *Hirudo*. This genus is represented in Australia—at any rate, in New South Wales—by *H. australis*, Besisto, described by Grube (*loc. cit.*, p. 40) and figured by Schmarda.† But this species differs from the New Zealand species in colour, size, and the character of the jaws.

Hirudo antipodum, n. sp.

Diagnosis.

The general *coloration* (in specimens preserved in formol) is as follows: Ground-colour of a pale coffee-brown, faintly toned with reddish ventrally. On the dorsal surface are 5 black bands—viz., (*a*) a median band of considerable width (about a quarter the breadth of the body); (*b*) a supramarginal band rather narrower than this, and separated from the former by a space wider than itself; and (*c*) a linear streak separating this strip of ground-colour into two nearly equal strips. The ventral surface pale-brown, slightly speckled with black, and usually with an irregular line of small black dots near the margin.

Size.—The largest specimen is 48 mm. in length by 12 mm. in breadth, the greatest diameter being in the posterior third of the body; sucker 8 mm. in diameter. Smallest individual, 21 mm. by 6 mm., and the sucker 3 mm.

Jaws.—Small, concealed by three large fleshy folds arranged alternately with the jaws; the latter are longer than broad, with a straight inner margin and convex outer border. There are no distinct denticles, but mere irregularities of the inner margin.

Locality.—Open Bay Island, off the west coast of the South Island, New Zealand. In amongst the wet roots of grasses, &c., at the bottom of nests of *Puffinus* sp.

Description. — The specimens were preserved in formol. The colour in the preserved leeches is a coffee-brown, but in formol a pigment has been extracted which colours the solution green. Some of the individuals were, on arrival at the Museum, transferred to alcohol. This is not discoloured, and the worms are a little darker in tint than the others.

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* Whitman, Q.J. Mic. Sci., xxvi., 1886, p. 316.

† Schmarda, Neue Wirbellose Th., 1, (2), 1861, pl. xvi., fig. 140.

The median dark band varies in width and in density of pigmentation. In some cases the pigment-spots are so close together as to form a black band; in other cases they are less close, so that the ground-colour shows between them and interrupts the continuity of the band. In some cases the lateral margin of this band extends outwards irregularly at intervals across the neighbouring field of ground-colour, and this may take place to such a degree that the median band coalesces with the intermediate linear streak (*c*). In one specimen the median band (*a*) is separable into 3 bands—viz., a pair of admedian black linear streaks and a median area in which the pigment-spots are less closely aggregated. Naturally, the width of the supramarginal band varies to some degree, though there is always a distinct band of ground-colour between it and the actual margin of the body.

As to size, it is evident that some of my specimens are quite young and probably immature. The cocoons are empty: perhaps the smallest individuals are but recently hatched.

Dimensions in Millimetres.

	Length.	Breadth.	Height.	Sucker.
(*a*)	48	12	8	8
(*b*)	40	10	6	7
(*c*)	39	9	6·5	7
(*d*)	26	7	..	7
(*e*)	24	10	6	5
(*f*)	21	6	4	3

One of the individuals (*g*), which may be the one that bit Mr. Dunlop, is gorged with blood, and is much redder than the rest. It is strongly convex ventrally, and the back is longitudinally bent upwards. Its dorsal length (along the curve) is 22 mm., and ventrally (along the curve) 38 mm., greatest breadth 11 mm., and height 8 mm. The sucker is only 5 mm. diameter with margins inflated; it is thus a small individual.

I have placed this leech in the genus *Hirudo*, for it possesses 5 pairs of eyes, on annuli 1, 2, 3, 5, and 8; and the segmental sensillæ on annuli 8, 11, 14, 19, and subsequently on every fifth annulus up to the 94th. Then we come to abbreviated segments, and the sensillæ occur on the 97th and 99th, but I could not detect any on the 101st annulus. Both the 101st and 102nd are very small, and the anal depression affects them both.

Of the sensillæ I could detect 8 rows on the dorsal surface, but I could not detect any on the ventral. The sensillæ are all situated on the ground-colour, and were very distinct

in the formol specimens when I examined them on arrival, but at the present time I find it more difficult to distinguish them; and they were much less evident in the alcohol specimens. In the formol the sensillæ appeared of a different tint from the surroundings—of a more orange colour; and the sense-organ at the tip of the papilla was whitish.

With regard to the head, I carefully looked for any preocular annuli, such as Castle* refers to, but there are none in this species. Indeed, the first distinct annulus crossing the body transversely is that which carries the 3rd pair of eyes. The anterior semicircular margin of the head is marked by a series of furrows at right angles to the margin, and traceable on to the ventral surface into the oral sucker. Thus, at the extreme anterior extremity the grooves are sagittal, and as we trace them backwards they gradually assume a more transverse direction till the 3rd eye is reached. These furrows delimit small quadrate areas, and of these there is a couple between the right and left eye of the first pair—*i.e.*, one on either side of the median line. The 1st eye lies in the second of such areas; then between the 1st and 2nd eye is an area; the 2nd eye occupies one; then another between 2nd and 3rd eye. These small areas appear to bear the same relation to these eyes as does the annulus between the 3rd and 4th eyes. It may be that each such "area" represents an annulus of some primitive leech, but I find no mention of them in Whitman's paper, though in the beautiful drawing by a Japanese artist of *Hæmadipsa japonica* (pl. xvii., fig. 6) similar "areas" exist, having the same general arrangement. In this case, however, they resemble the quadrate, flattened papillæ which cover the surface of the body generally. My material of hirudineans, and the literature at my disposal, does not permit me to pursue the subject further; but as we have reason to believe that the "head" is composed of abbreviated somites, and this abbreviation is more or less marked in different genera, it seems a possible view that these "areas" have some connection with the missing annuli of the ocular region.

The first complete annulus is the 5th. This "buccal" annulus forms the edge of the hinder margin of the oral sucker, or mouth; and it is distinct from the 6th, though it is very narrow in the ventral region.

The genital pores have the usual position—viz., between the 30th and 31st annuli; and between the 35th and 36th there is a fairly long protrusible cirrus. I have been unable to detect the nephridiopores.

* Castle. Proc. Amer. Acad. Arts and Sci., Philadelphia, xxxv., 1900, p. 285.

Of internal anatomy I can only note that the alimentary canal is similar to that of the medicinal leech, since I have not as yet examined the other organs.

The most characteristic feature about this new species is the existence of three fleshy folds concealing the jaws. If the mouth, or oral sucker, be viewed from below three semicircular ridges are seen, one transversely disposed—ventral ridge—the other two being obliquely placed, and meeting in the median dorsal line. These folds may be termed "lips," and correspond to structures which occur, indeed, in *Hirudo medicinalis* (with which alone I have had an opportunity of comparing them by personal observation), but are quite feebly developed and inconspicuous. In our native leech, on the other hand, they are so prominent as to be mistaken at first for the jaws, but that they are arranged in the wrong way. Microscopic examination, however, shows that they are highly vascular in structure and hood-like in form, each being concave towards the median plane and convex externally, with a thickened free margin.

On turning these aside, or by cutting away the ventral "lip," the true jaws are exposed in the usual position—viz., a median dorsal jaw and a pair of latero-ventral jaws—alternating, therefore, with the "lips." But the form of the jaws differs from that of other species of *Hirudo* (so far as I am aware) in that they are not semicircular, with the basal axis longer than the vertical axis. On the contrary, in *H. antipodum* the vertical axis is greater than the basal axis, the median (*i.e.*, oral) margin is nearly straight, and the outer margin convex. Further, there is practically an absence of denticles, such as occur in the other species of the genus. Nevertheless, the oral margin has its cuticle raised into a series of irregular rounded prominences, which appear to be due to oblique foldings of the cuticle, and these are arranged in a single series. But, although practically edentulous, we have the evidence of Mr. Dunlop that the jaws are sufficiently armed to pierce the human skin.

So different are these jaws from other species of *Hirudo* that one is tempted to make a new genus for our species; but as in all other external features, at any rate, this species agrees with other species of the genus *Hirudo* I have considered it better to leave it in this genus till I have worked out the internal anatomy, and especially after reading Whitman's remarks (*loc. cit.*, p. 366) on the genus *Hæmopis*, which he includes within the genus *Hirudo*, since the only character in which the two genera differ lies in the less number of denticles in the former: "In view of the great variability in the number of denticles not only among different species of one and the same genus, but also among different individuals of

the same species, and even in the different jaws of the same individual, this distinction hardly deserves generic rank." On the next page (367) he considers this question a little more fully, and proceeds, "So long as the denticles are sufficiently numerous and well formed to enable the leech to live by sucking blood it is plain that the reduction has not reached a point at which the formation of a new genus becomes imperative." It is true that much systematic work has been done since Whitman's paper was published, but as I have not access to R. Blanchard's papers (except that dealing with the Italian leeches, in the Boll. Mus., Zool. Torino, ix., No. 192), and as my species does not fit into any of the genera (other than *Hirudo*) enumerated in Perrier's "Zoologie," I prefer, as I have said, to leave our New Zealand species in the genus *Hirudo*.

It may be well to mention that the edentulous leeches of Japan, referred to the genus *Whitmannia* by R. Blanchard (= *Leptostoma*, Whitman), differ in the details of the annulation of the body as well as in the position by the genital pores. Moreover, the genus consists of land-leeches.

The Cocoon.

The cocoon, of which I give a figure, agrees generally with the account given by Moquin-Tandon* of that of *Hirudo medicinalis* (p. 177 and pl. xi.). It is regularly ovate, of dark-brown colour and horny texture; it measures 14 mm. by 8 mm. over all. The outer surface consists of stiff horny filaments projecting outwards from a continuous horny membrane. The latter is marked by numerous shallow depressions, each irregularly circular, or, more properly, hexagonal or polygonal, in outline. The low walls which separate the depressions give origin, at the point where two or more meet, to short vertical filaments; these branch into two or three shorter threads, lying in a plane at right angles to the vertical filaments: these threads terminate in a small thickening, and interlace, or may even be united with neighbouring threads. In this way a very loose and easily broken felt-work is produced. The basement membrane, though tough, is quite thin, and on the inner surface is smooth and shiny, and marked by feebly convex areas corresponding with the shallow pits seen on the outside. I opened one cocoon, which was empty; and as they both floated in the preserving fluid I judge that the other is also empty. Probably the smaller leeches captured are only recently hatched, but there is no perforation in the wall of the cocoon.

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* Moquin-Tandon, Monogr. d. l. Fam. des Hirudinées, 1846.

EXPLANATION OF PLATE VIII.

Fig. 1. Outline of *Hirudo antipodum* (× 2) taken from a small specimen, which was not curved. (It appears desirable to insert this figure, as so few people in New Zealand seem to know a "leech"; the land-planarian is commonly referred to by this name.)

„ 2. View of the dorsal surface of the head (enlarged), showing the arrangement of eyes and sensillæ and pigmentation.

„ 3. View of a short portion of another individual, dorsal surface, in which the median black band is broken up into three narrow streaks. (× 2.)

„ 4. Under-surface of the head; *a*, *b*, the peculiar fleshy lips. (Enlarged.)

„ 5. The same, still more magnified, after a median incision through the body-wall and ventral lip has been made; the lips are turned aside so as to expose the three jaws (*j*). *m*, the muscles thereof.

„ 6. One of the jaws (camera, Oct. 1, obj. 3, Leitz), showing the feeble development of the denticular ridges.

„ 7. A cocoon (enlarged), the surface only partly filled in. In the middle is seen the external surface of the basal membrane; and, marginally, the felt-work. A, shows a piece of the surface, still more enlarged. B, the cut edge of the wall, showing the relation of the felt-work to the basal membrane.

Art. XXII.—*A Note on the* Oligochæta *of the New Zealand Lakes.*

By W. B. Benham, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 11th August, 1903.*]

During the year 1902 two young naturalists from the Old Country — Messrs. Keith Lucas and Hodson — visited this colony for the purpose of making a biological and topographical survey of the principal lakes. Mr. Lucas was good enough to hand over to me for identification all the *Oligochæta*, or annelids, which were collected by him. Naturally, I was delighted to have the opportunity of investigating the character of the deep-water fauna of our lakes, especially as, in the first place, such an opportunity is, in all probability, not likely to recur for several years; and, secondly, because our knowledge of the fresh-water annelids of the colony can be compressed into a very small compass. I propose to-night to give merely a brief summary of my results, a full and illustrated account of which I have sent to the Zoological Society.

The material upon which this paper is based consisted of thirty-three small tubes, containing about a hundred and fifty specimens, which, after examination, I find represent about a dozen species, all new to science, referable to nine genera (of which one is new), belonging to five families.

Family PHREODRILIDÆ.

Phreodrilus, Beddard.

1. *P. lacustris*, n. sp. Wakatipu and Manapouri.
2. *P. mauiensis*, n. sp. Taupo.

Family TUBIFICIDÆ.

Taupodrilus, n. gen.

3. *T. simplex*, n. sp. Taupo, Waikare, and Manapouri.

Limnodrilus, Claparéde.

4. *L. lucasi*, n. sp. Taupo and Rotoiti.
5. *L vejdovskyanus*, n. sp. Waikare and Waikaremoana.
6. *L.* sp. incert. (immature). Wakatipu and Manapouri.

Tubifex, Lamarck.

7. *T.* sp. incert. (immature). Taupo, Rotoiti, and Waikaremoana.

Family ENCHYTRÆIDÆ.

Enchytræus, Henle.

8. *E. simulans*, n. sp. Taupo.

Achæta, Vejdovsky.

9. *A. maorica*, n. sp. Manapouri.

Family HAPLOTAXIDÆ.

Haplotaxis, Hoffmeister.

10. *H. heterogyne*, n. sp. Wakatipu.

Family MEGASCOLECIDÆ.

Sub-family Megascolecinæ.

Diporochæta, Beddard.

11. *D. aquatica*, n. sp. Manapouri.

Plutellus, Perrier.

12. *P. lacustris*, n. sp. Wakatipu.

All these worms are of small size, none exceeding 3 in., the majority but little more than 1 in. in length, while one was only about $\frac{1}{6}$ in.; and the diameter of the majority does not exceed the thickness of a stout pin. Hence the work of identification was by no means an easy one, necessitating the constant use of higher powers of the microscope, for the external differences between these fresh-water worms lie chiefly in the form and number of the small bristles with which each segment of the body is provided, and these

bristles had to be examined under an oil-immersion lens for thorough investigation. After sorting the worms into groups in this manner one or more of each group was then stained and mounted entire for a preliminary examination of the internal structure; and further examples of each had to be cut into a series of transverse sections and series of longitudinal sections, each section being about $\frac{1}{200}$ in. in thickness, or even less, in order that the internal anatomy might be thoroughly explored, for by this method alone can the differences between species, and even genera, be properly determined. Those who have had experience in this minute microscopic work will perhaps appreciate the length of time required and the tedious nature of the work of identification.

Of the nine genera, five are common in Europe and North America, the only localities in which these annelids have received adequate attention; these five are—*Tubifex*, *Limnodrilus*, *Enchytræus*, *Achæta*, and *Haplotaxis*.

Of these probably cosmopolitan genera *Limnodrilus* and *Haplotaxis* have already been recorded from New Zealand, but the species of *Limnodrilus* referred to by Beddard was immature, and was too insufficiently characterized to be identifiable; I have found it necessary to make two new species of *Limnodrilus*. Of *Haplotaxis* one species has hitherto been recorded from New Zealand, one from Europe, one from America. I thus add a fourth to the list—a second from New Zealand.

A sixth genus, *Phreodrilus*, has hitherto been found only in South America, Falkland Islands, Kerguelen, and New Zealand. I have to add, as a result of my investigations, two new species, one of which, unfortunately, is represented only by a single immature individual; but the other, *Ph. lacustris*, is common in Lake Wakatipu, and one interesting fact about it is that it is more nearly allied to the Kerguelen Island species than to the other New Zealand species. This is a very remarkable fact, especially in conjunction with similar facts observed in the case of certain of our earthworms (*Notiodrilus*) presenting a similar distribution, where the species from the Macquarie and from the Auckland Islands are more nearly related to the South American and Falkland Island species than to those living on our mainland.

Two other genera, *Plutellus* and *Diporochæta*, are Australian. The former has not hitherto been met with here, though two species of the latter have been recorded.

The ninth and last genus differs from any hitherto known to science, and I have named it *Taupodrilus*, to indicate the fact that it occurs characteristically in Lake Taupo.

When we consider the many endemic genera of terrestrial worms occurring in New Zealand, and the generally unique

character of the earthworms, it appears somewhat disappointing to find such an absence of peculiar genera in the case of the aquatic worms. Nevertheless, this is in accordance with the usual character of fresh-water fauna the world over—at any rate, in the case of the smaller invertebrates—and especially of the *Oligochæta*, for there is a remarkable uniformity in the aquatic annelids in all parts of the world hitherto explored, with a mere sprinkling of peculiar forms. And this difference in the facies of the terrestrial and aquatic annelids is due to the difference in the manner in which the two kinds of *Oligochæta* are transported from one country to another.

Now, as I have pointed out in previous communications, earthworms can only be distributed by their own active locomotion or migration through or on the earth, hence continuous land-areas—at some period or another—are necessary to explain the occurrence of allied species in two spots now isolated by stretches of sea. But in the case of the fresh-water worms, which are of small size, the means of dispersal from one country to another does not necessarily depend on their own emigration; and though in this case we are still somewhat in the dark as to the exact manner of transport, yet from analogy with what we know to be the mode of dispersal of the smaller aquatic molluscs, crustacea, and insects it appears extremely probable that these small aquatic worms may be conveyed by birds, especially by wading-birds, such as the red stilt and heron, and by ducks like the teal, grey duck, and crested grebe, which, dabbling in the mud at the margin of a lake or in the neighbouring swamp or stream, carry away some of this mud on their feet. The occurrence, for example, of *Plutellus* in Wakatipu and of *Diporochæta* in Manapouri, both of which worms have their home in Australia, is probably to be explained by their being carried, or by their cocoons being carried, in this mud adhering to the feet of such birds. The length of time required by a fairly strong-flying bird with a wind behind it in passing across the Tasman Sea would not be more than thirty-six to forty-eight hours — and perhaps even less—and during this time, if the worm were enclosed in a ball of earth, it is quite possible that sufficient moisture would be retained in the centre of the ball to preserve the life of this small worm. At any rate, the cocoon would easily withstand a considerable amount of drying-up, and when the bird alights on the shore of the lake the cocoon, deposited in the water, would give the species a start in the new locality, and as each cocoon contains several eggs the species would have a fair chance of survival. Since the mud continues to adhere to the feet, it is clear that a certain amount of moisture persists, otherwise the mud would crumble away during the journey. Now, M. De Guerne has investigated the mud ad-

herent to the feet of wild ducks in Europe, and found it to contain, or, rather, to give rise to, after proper cultivation, numerous small creatures, such as nematodes, rotifers, eggs of water-fleas, and other small organisms, while other records state that small mollusca have been found adhering to the feet of birds after long periods of flight.

The lakes that were explored during the survey are Wakatipu and Manapouri in the South Island, and Taupo, Rotoiti, Waikare, and Waikaremoana in the North.

The annelid fauna of the northern set of lakes is quite different from that of the southern couple, not merely in the species, but in the genera; and, as we should expect, the different lakes in each group are occupied by different species, though there are one or two species common to two or more lakes. Only in the case of one species—viz., *Taupodrilus simplex*—do I find the same worm occurring both in the northern and southern lakes.

The richest—*i.e.*, most varied—fauna was obtained from Manapouri, where five species, representing as many genera, belonging to four families, were collected in only six spots. But Taupo is nearly as rich, where five species, belonging to five genera, representing three families, were collected at four stations.

TABLE SHOWING FAUNA OF THE LAKES EXPLORED.

Species.	Number of Individuals.	Depths, in Feet.	Number of Stations.
WAKATIPU: Maximum depth, 1,242 ft.; number of stations at which *Oligochæta* were obtained, 10; total number of individuals obtained, 37.			
Plutellus lacustris	17	300–1,200	7
Phreodrilus lacustris	10	300–1,000	3
Haplotaxis heterogyne	2	550	1
Limnodrilus, sp. A, inc.	1	1,000	1
MANAPOURI: Maximum depth, 1,458 ft.; number of stations, 6; total number of specimens, 16.			
Phreodrilus lacustris	6	150–500	1
Taupodrilus simplex	6	10–1,000	2
Limnodrilus, sp. B, inc.	1	150–500	1
Achæta maorica	1	350	1
Diporochæta aquatica	2	350–500	2
TAUPO: Maximum depth, 534 ft.; number of stations, 4; total number of specimens, 32.			
Taupodrilus simplex	11	150–500	2
Phreodrilus mauiensis	1	150–500	1
Limnodrilus lucasi	12	300–450	1
Enchytræus simulans	7	?	1
Tubifex, sp. inc.	1	?	1

Table showing Fauna of the Lakes explored—*continued.*

Species.	Number of Individuals.	Depths, in Feet.	Number of Stations.
Rotoiti: Maximum depth, 228 ft.; number of stations, 2; number of specimens, many.			
Limnodrilus lucasi	Numerous	100–228	1
Tubifex, sp. inc.	2	..	1
Waikare: Maximum depth, 9 ft.; number of stations, 1.			
Limnodrilus vejdovskyanus ..	30	9	1
Taupodrilus simplex	1	9	1
Waikaremoana: Maximum depth, 846 ft.; number of stations, 3; number of specimens, 16.			
Limnodrilus vejdovskyanus(?) ..	6	800–840	1
Limnodrilus, sp. inc.	1	200–750	1
Tubifex, sp. inc.	1	..	1
Indeterminable fragments	8	80	1

Remarks on the above Table.

Lake Wakatipu thus yielded, in eleven hauls at different stations, a total of thirty specimens, which fall into four species, belonging to as many genera, and representing four families. Of these *Limnodrilus* was represented by a single immature individual. But the commonest species is *Plutellus lacustris*, which was obtained at eight stations widely separated and at depths varying from 300 ft. to 1,200 ft. It occurs both in the North Arm and in the South Arm of the lake. *Phreodrilus* was obtained at only three stations in the South Arm, in depths from 300 ft. to 1,000 ft.

Lake Manapouri, whose greatest depth Mr. Lucas found to be 1,458 ft., yielded sixteen specimens for six hauls. These fall into five species, belonging to as many genera, and representing four families. But here again a single specimen of *Limnodrilus* too immature for identification is included. It is possible that the hauls were made in depths beyond that at which the members of this genus dwell, for they are more numerously represented in the shallower lakes of the North Island. The remaining worms, however, are very interesting —firstly, the small worm *Achæta maorica*, represented, unfortunately, by only a single individual, is the fourth species of the genus, and has hitherto only been known in Europe. Then, the new genus *Taupodrilus* occurs at two stations, ranging from 10 ft. to 1,000 ft. in depth—the only species which is common to the lakes of the two Islands. *Phreodrilus* is represented by the same species as in Wakatipu. And, finally, *Diporochæta aquatica*, the first member of the genus

recorded from such deep water—indeed, hitherto the New Zealand species have only been recorded from swamps.

Turning to the North Island lakes, Taupo presents us with the richest fauna. Its depth is only 534 ft., very shallow as compared with Wakatipu. It yielded thirty-two specimens for four hauls, belonging to five genera. Of these *Taupodrilus* is the most interesting, and is widely distributed, having occurred at two spots ranging from 150 ft. to 500 ft. in depth; and it is apparently pretty common, as about a dozen individuals were collected. *Limnodrilus lucasi* and *Enchytræus simulans* are also about as numerous, though only obtained at one spot each. In this lake I find a single specimen of a second species of *Phreodrilus*.

Waikare, with a maximum depth of 9 ft., yields chiefly *Limnodrilus*, which genus is represented by a distinct species in Rotoiti, where it occurs in abundance.

From Waikaremoana, which with a depth of 846 ft. ought to have yielded some interesting forms, I only received sixteen specimens, which, unfortunately, are so badly preserved as to be unidentifiable, though some at least belong to the genus *Limnodrilus*.

Art. XXIII. — *An apparently New Species of* Regalecus (R. parkeri).

By W. B. Benham, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 9th June, 1903.*]

Plate IX.

In November, 1902, I received a silvery Oar-fish, which was washed ashore in Deborah Bay, near Port Chalmers, in Otago Harbour. It was observed with its head downward and the tail flapping above water in the air.

The colour was silver, without—so my informant states—any other coloration. The long nuchal fin-rays were broken off at the base, as also were the pelvic fin and the tail, so that it is possible that the two former fins may have had the bright-red colouring known in *R. glesne*. The silver was marked by 14 dark transverse bands set at fairly regular intervals from the back of the head to the end of the body. Each band extends over the entire depth of the body, and is separated from its neighbours by a space about equal to its own length, which varies from 1½ in. to 2 in. (30 mm. to 50 mm.), the latter being the length of the bands near the

middle of the body. These colour-bands are not black, but extremely pale grey, and could only be recognised by reflection in certain lights, the grey being due to minute pigment-cells below the silver.

The fish is remarkable for its very great length as compared with its vertical height, being much more ribbon-like than other ribbon-fishes. Its total length (without the caudal fin) is 45 in. (1,144 mm.); it greatest height (at the level of anus) is only 0·75 in. (18·75 mm.); its thickness at this point is $\frac{9}{32}$ in. (7·3 mm.). This brings the ratio of length to height to about 60.

The head measures $2\frac{1}{8}$ in. in length (53 mm.), and $\frac{7}{8}$ in. in height (21 mm.). Diameter of eye $\frac{1}{2}$ in. (12 mm.); distance from anterior margin to tip of retracted snout is $\frac{3}{4}$ in. (18 mm.).

Anus, $13\frac{1}{4}$ in. (337 mm.) from snout.

Fin-formula: D., 7/390; P., 10; V. (?).

Height of body, $\frac{1}{60}$ of the total length; length of head, $\frac{1}{21}$ of the total length; pre-anal region to total length is 1 to 3·3.

The dorsal fin is about half the height of the body, and there are 9 fin-rays to the inch anteriorly—or, roughly, about 390 fin-rays altogether. The anterior rays measured along their length are $\frac{5}{8}$ in. (15 mm.); in the hinder part they are about $\frac{1}{2}$ in. (12 mm.) long. The membrane reaches nearly to tips of the rays. The anterior or nuchal portion of the fin was damaged, but the bases of 7 rays remain, which are stouter than the usual rays, and no doubt were elongated, as in *R. glesne*. The pectoral fin is $\frac{7}{16}$ in. long, with 10 rays; the pelvic (broken) are represented by a pair of minute knobs just behind the level of the pectorals on the throat. No doubt they were elongated in life.

Teeth absent in the upper jaw, but there are two pairs of delicate conical teeth far forward in the lower jaw, and on the palate a small median tooth.

The lateral line has a characteristic course: starting from the upper part of the back of the head, it passes rapidly downwards behind the pectoral fin to gain the lower part of the side, about $1\frac{1}{8}$ in. (28 mm.) behind the head. Thence the right and left lateral lines run backwards parallel, one on each side of the narrow belly close to the ventral mid-line and separated by a distance of $\frac{1}{8}$ in. (3 mm.).

The head has black (not dark-blue, as in *R. glesne*) pigment bordering the lips, and a curved band of the same colour across the forehead, concentric with but slightly removed from the hinder border of the maxillary bone. The top of the head is black. The iris is also partially black, so arranged that the silver portion is a vertical oval, there being a greater width of pigment anteriorly to the pupil than posteriorly.

There are black pigment-spots along the base of dorsal fin and along side of body at posterior end.

The gonad is 7 in. long.

From the above it will be seen that the present fish does not agree with any of those enumerated by Dr. Günther in the British Museum Catalogue ("Fishes," iii., p. 300, *et seq.*), but it most nearly approaches the Indian species *R. russelii*, Shaw, which is figured in Day's "Fishes of India," pl. 79, fig. 2. This is 2 ft. 8 in. in length—*i.e.*, 816 mm. For this species Günther (p. 311) gives the following diagnosis:—

"D., 4–5/320; C., (?); P., 11; V., 1. The height of the body is one-twentieth of the total length. Teeth none. Caudal rays distinct."

The figure given by Day is 193 mm.—*i.e.*, about a quarter the natural size. The greatest height is at the head; thence the dorsal surface slopes rather rapidly at first and then more gradually to the end of the body (a little more rapidly apparently than in our specimen). Height at level of pectoral is 8 mm. on figure (*i.e.*, 32 mm. in the fish); height at middle of body, 4 mm. on figure (*i.e.*, 16 mm. in the fish); length of head, 10 mm. on figure (*i.e.*, 40 mm. in the fish); diameter of eye, 2 mm. on figure (*i.e.*, 8 mm. in the fish); anterior margin to snout, 2 mm. on figure (*i.e.*, 8 mm. in the fish); height of dorsal fin in mid-body, 2·5 mm. on figure (*i.e.*, 10 mm. in the fish).

Thus the ratio of height to length is $\frac{1}{4\cdot7}$ *contra* (Günther). Day states of the dorsal-fin rays that the "central rays are the longest."

This fish is evidently different from Day's, and I propose the name *R. parkeri*, in memory of my predecessor, who made a careful study of the anatomy of *R. glesne*. At the same time it is possible that the present fish is the young of some known species, but it is convenient to record the occurrence under a distinctive name.*

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* Since writing this article I have received a second specimen of this fish, captured at Stewart Island by Mr. Traill, and given to me by Mr. G. M. Thomson. This individual is much longer than the one described above, its measurements being as follows: Total length, 75 in.; greatest height (exclusive of fin), 1·75 in. The ratio of length to height is about 43 (the fish is proportionately higher than the above); length of head, 3 in.; distance of anus from tip of snout, 22 in. There are, on the average, some 7 fin-rays to the inch, which gives a total of 525 fin-rays. The tail, though without the caudal fin, is uninjured, so that we may supplement the above account. At the hinder end of the body, about $\frac{3}{16}$ from extreme tip, the dorsal fin ceases, and the ventral body-wall suddenly curves upward and backward to meet the dorsal line in a sharp point. On the upper surface, close to the point, are the broken stumps of three or four fin-rays.

Art. XXIV.—*A Species of* Ixodes *parasitic on the Grey Duck.*

By Chas. Chilton, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

Plate X.

In May, 1903, Mr. W. W. Smith, of Ashburton, sent me some specimens of a "tick" found on a specimen of the grey duck (*Anas superciliosa*), with the request that I would examine them, and describe them, if necessary.

The specimens forwarded appear to belong to the genus *Ixodes*, Latreille, of which five species have been already described as parasitic on various New Zealand birds. Of these three were described by the late W. M. Maskell—viz., *I. eudyptidis*, from a penguin;* *I. apteridis*, parasitic on the North Island kiwi (*Apteryx mantelli*);† and *I. aptericola*, found on the South Island kiwi (*Apteryx australis*).‡ Mr. T. W. Kirk has described one species, *I. maskellii*, obtained from young specimens of the pencilled albatros, and has also recorded the fact that he found on a large gull a tick exactly similar to the one from the crested penguin described by Mr. Maskell.§ A fifth species has been more recently described by M. Neumann in a paper which I have had no opportunity of consulting.|| I have been unable to identify my specimens with any of the others described from New Zealand, and have therefore ventured to describe them as new. I do so, however, with considerable hesitation, as I have not specially studied the group. I hope, however, that the description and figures given below will be sufficient for future identification. In the general shape and markings on the body the species here described seems to rather closely resemble *Ixodes maskellii*, T. W. Kirk, but in the absence of figures of that species I have not ventured to refer my specimens to his species.

Ixodes anatis, sp. nov. Plate X., figs. 1 to 6.

Female.—Body broadly elliptical, slightly constricted at the sides; cephalic shield lighter in colour than rest of body, very small, oval, narrowing in front, only partially visible in dorsal view. On dorsal surface two shallow grooves or markings extend backwards and outwards from the cephalic shield, and lead to two irregular depressions situated about one-third the length of the body from the anterior end; from these depressions extend two well-marked lateral grooves, curving slightly inwards and reaching nearly

* Trans. N.Z. Inst., xvii., p. 19. † *L.c.*, xxix., p. 291. ‡ *L.c.*, xxix., p. 29. § *L.c.*, xix., p. 65. || Mem. Soc. Zool. France, 1899, p. 132.

to the posterior end of the body. An indistinct median groove runs forward from the posterior extremity of the body and gradually disappears before reaching as far forward as the depressions. Whole dorsal surface free from hairs, but marked with very fine parallel striæ, which anteriorly are concentric with the margins of the cephalic shield, but soon become transverse. On the ventral surface two grooves arise at the bases of the legs and run backwards, at first nearly parallel, but afterwards curving slightly outwards, and not reaching so far as the posterio-lateral margins of the body. Posteriorly is a median groove extending from the posterior margin for nearly one-third the length of the body; it is well-defined anteriorly, but becomes shallower and less distinct posteriorly.

Rostrum and palpi short, scarcely visible in dorsal view; rostrum cylindrical, straight, proximal two-thirds smooth above, distal third provided with numerous recurved hooks; on the under-surface these hooks extend along two-thirds of the length and proximally become arranged in four rows, the teeth of the inner row smaller than those of the outer. Palpi straight, not extending beyond the end of the rostrum, only the two terminal joints distinct; penultimate joint nearly twice as long as the terminal, slightly narrowed at the base; terminal joint rounded at the end, and with an oval marking on the under-surface; both joints with a few fine scattered hairs. Legs with the last two joints indistinctly separated, the last bearing two strongly curved claws arising from a small pad.

Size—length, 10 mm.; breadth, 5 mm.

Male.—Smaller specimens (length, 3 mm.; breadth, 1·5 mm.), which are presumably males, are similar in most respects to the females, but have the cephalic shield darker in colour and the grooves on the dorsal and ventral surfaces less well marked, and bear a few very fine hairs sparsely scattered over the body.

The colour of the animals when alive was, according to Mr. Smith, "females dull-green, males brownish-green."

Type specimens have been deposited in the Canterbury Museum.

I have to thank Miss E. G. Freeman, of the Christchurch School of Art, for drawing for me figures 1 and 2, representing the dorsal and ventral surfaces of the female.

DESCRIPTION OF PLATE X.

Ixodes anatis, Chilton. ♀.

Fig. 1. Dorsal view of female, × about 4 times.
„ 2. Ventral view of the same, × about 4 times.
„ 3. Rostrum, seen from above, × about 60 times.
„ 4. Rostrum, seen from below, × about 60 times.
„ 5. Fourth leg, × about 30 times.
„ 6. End of same, more highly magnified.

III.—BOTANY.

Art. XXV.—*Plants naturalised in the County of Ashburton.*

By W. W. Smith.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

It is now over thirty-one years since the late Mr. J. F. Armstrong, Curator of the Botanical Gardens, Christchurch, contributed the first paper to this Institute* on the naturalised plants of the then Province of Canterbury. The list attached to his paper enumerated 171 species of naturalised plants observed by Mr. Armstrong in the neighbourhood of Christchurch. "This," he wrote, "is certainly very remarkable when we consider that twenty years ago few or none of these plants were known in the province." In deploring the rapid extinction of many species of native plants, he also remarked that "the indigenous flora seems to have arrived at a period of its existence when it has no longer strength to maintain its own against the invading races." During the intervening thirty-one years since Mr. Armstrong's paper was published the number of species of naturalised plants has vastly increased, while their phenomenally rapid dispersion, and, in many cases, aggressiveness, has proved a serious menace to practical and profitable farming in Canterbury and in many other extensive farming-areas in New Zealand.

The settlement of the County of Ashburton began in 1851, when a number of sheep stations or runs were let by the Canterbury Provincial Council to gentlemen some of whom are now honoured names in the history of the province. The Ashburton County extends from the Rakaia to the Rangitata River, and from the sea-shore on the east coast westward to the dividing-range which is also the eastward boundary of the County of Westland. The flora of the whole county was then in all its native beauty and splendour. Extensive areas of magnificent primeval bush existed at Alford Forest and Springburn, and at Peel Forest, on the south bank of the Rangitata River. After twenty-five years of great activity in the sawmilling industry these richly timbered forests are now

* Trans. N.Z. Inst., vol. v., p. 284.

almost "cut out." Their sites, which will remain for a few years more or less strewn with decaying stumps and trunks, form valuable pastoral lands, on which all introduced fodder and other plants generally grow luxuriantly. The broad Canterbury Plains were "billowy bays of grass," clothed with dense tussocks comprising several species of *Poa* (chiefly *Poa australis*), with extensive groups of the palm-lily (*Cordyline australis*) and *Discaria toumatou*, extending from the sea-shore to the slopes of the fore ranges. When the fierce north-wester blew across the plains the successive gusts produced the wave-like motions of the dense and close-growing tussocks, akin to those observed by "Australian Felix" on the grassy plains of Victoria. In the hot sunshine the tussocks absorbed and retained a great amount of heat, which, when the north-wester leached through them, produced, especially during the night, the hotter wind experienced by the early settlers domiciled on the lower half of the Canterbury Plains. Amongst the tussocks flourished many species of interesting native plants, most of which have now almost vanished from the plains. On the swampy land extensive areas of *Phormium tenax*, with numerous species of aquatic and sub-aquatic plants, grew luxuriantly. The draining of the extensive swamps—a work of great colonial enterprise—and the subsequent depasturing of farm stock thereon, has almost completed the annihilation of this class of native plants on the plains.

The phenomenally rapid dispersion and naturalisation of numerous species of exotic plants in New Zealand, and the equally rapid disappearance of many species of native plants from their habitats, during the half-century of British colonisation will ever remain a subject of great interest to botanists. Mr. Armstrong's remarks *in re* the "indigenous flora having arrived at a period of its existence when it had no longer strength to maintain its own against the invading races" are very suggestive. Although we know that the native flora possess equally perfect methods of fertilisation in most species to those invading plants that have supplanted it in many large areas, its disappearance must be due to other causes at present imperfectly known. In almost every district, especially on the poorer lands, that remained for many years unploughed and almost untouched by stock, the displacement of the native plants by more hardy alien species proceeded apace. The conquest of the New Zealand flora by the northern invaders is due in some measure to their greater development "in the most extensive land-area of the globe, where competition has long been most severe and long continued,"* which

* "Island Life," p. 511.

has fitted them to supplant the less vigorous antipodean plants in a soil and climate perfectly adapted to their habits. With few exceptions the indigenous plants of New Zealand never attained the development necessary to fit them in the struggle with the strongly developed European plants. On the deeper and richer land of the plains, where the close-growing tussocks (*Poa australis*) grew high and vigorous, they more than any other class of plants prevented the dispersal and growth of introduced species.

The annual practice of burning the extensive sheep-runs to promote fresh growth of the tussocks, and the subsequent sowing of the burned areas by scattering weed-infested seed broadcast over them, will explain the occurrence of many species of exotic plants naturalised on the upland country in the early years of settlement. With so much weed-infested seed sown on the virgin soil, and considering the lack of proper tillage the land received, we should not be surprised at the presence in the colony of so many species of exotic plants and plant-parasites, interesting though they are to the botanist and zoologist. We also know that much valuable land was purchased and farmed in the early days of Canterbury by many quite inexperienced men, whose lack of knowledge of plants and indifferent style of farming were the chief causes of the rapid spread of exotic plants now naturalised in the county and elsewhere. Many species flourish in imperfectly tilled land where many valuable economic plants and cereal crops could make little growth.

Unlike the river-beds of Britain, the broad, warm, sandy, and silty flats of the glacier and other rivers crossing the Canterbury Plains provide more congenial conditions and sites for the growth of many representatives of the Scandinavian flora, where they frequently attain abnormal dimensions. A European botanist would be charmed to view the luxuriance and beauty of many species of British plants naturalised in New Zealand. When I visited the lower gorge of the Rakaia River in February, 1901, the more swampy parts were ablaze with the flowers of large masses of *Erythræa centaurium*, *Prunella vulgaris*, *Mimulus moschætus*, *Vicia tetrasperma*, *Ænothera biennis*, *Geranium molle*, *Galium aparine*, *Bellis perennis*, *Crepis virens*, *Bartsia viscosa*, *Plantago lanceolata*, *Trifolium pratense*, and *T. repens*. I had not previously observed these plants display such great vigour nor attain such perfection of growth. The drier flats were also ablaze as far as the eye could see with the orange-coloured flowers of *Hypochaeris radicata*. On the small shingle-fans at the mouths of the numerous gullies opening into the Rakaia Valley *Carduus lanceolatus* grew in extensive masses, so high and strong as to be quite impassable in some places on horse-

back. This thistle is not now so aggressive on newly broken-up land in the county as formerly.*

Every year, during our frequent botanical and entomological excursions, we discover alien species of plants occurring or observed for the first time in the country. It is noteworthy how isolated and strictly local some species are, and remain almost stationary, while others multiply and disperse over large areas within a few years. Some recent introductions or new arrivals in this district have increased and spread at a remarkably rapid ratio compared to many other species which were earlier comers. On the 10th January, 1899, we discovered the first specimens of *Polygonum lapathifolium* met with in the county. Since that date it has spread up the river, and is now annually plentiful, especially on the more silty flats. Seeing that this species spread up along the river, its fine seeds were probably carried in the plumage and adhering to the feet of the numerous sea-birds nesting on the river-flats during the summer and autumn months. On the 20th April, 1900, my late son, Walter Valentine, discovered a few flowering plants of *Stachys annua*. This species is mentioned by Bentham as having been only once found in a field in Kent, England, which had been sown with seed obtained from abroad. I submitted fresh specimens of the plant to Mr. G. M. Thomson, Mr. T. F. Cheeseman, and Mr. J. B. Armstrong, and these botanists referred to its naturalisation on the Canterbury Plains of New Zealand as an interesting fact in the artificial distribution of plants. The species is very rare, and occurs in one locality only, where I found five plants in bloom in April last.

For many years it has been the custom of a number of residents of Ashburton to cart garden-rubbish, including offcast plants and dried seed-bearing stems of plants, and deposit them on the open river-bed. From this source arose several species of plants now abundantly naturalised on the river-flats. I have also observed new-comers appear on the sites where straw and hay had been deposited that had been imported in packing-cases. These were plants that generally compose some of the undergrowth of English cornfields and the chief vegetation of English meadows. They comprised *Carduus lanceolatus*, *Capsella bursa-pastoris*, *Papaver rhœas*, *Lepidium ruderale*, *Silene inflata*, *Senecio vulgaris*, *Chrysanthemum segetum*, *Sonchus arvensis*, *Polygonum aviculare*, *Lolium perenne*, *Bromus mollis*, *Cynosurus cristatus*, *Holcus mollis*, and *Avena fatua*. The latter plant has proved a great nuisance in fields of oats for many years past.

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* "Plant Acclimatisation" (G. M. Thomson), Trans. N.Z. Inst., vol. xxx., p. 313.

From numerous inquiries instituted among the early settlers I have ascertained that every crop they sowed, be it cereal or fodder, new plants appeared on their farms. Some species would grow vigorously for a few years, and in a few more years they would decrease and disappear. It is generally difficult or impossible, from the vague descriptions the old settlers give of these plants, to identify them accurately. But probably they remained so long as the rich virgin soil retained certain plant-food necessary to sustain them, and when the land became impoverished by repeated and unscrupulous cropping without restoring the exhausted elements of the soil they were replaced by more vigorous species better adapted to the changed conditions. Nine years ago *Scandix pecten-veneris* was very abundant and intrusive, and covered acres of good land in some localities; but it is now comparatively rare. Many other species of exotic plants have also become less numerous within the same period. Warm seasons or continuous periods of dry, warm weather are more favourable to the development of some introduced plants than to others. During the drought and hot weather experienced on the Canterbury Plains in the years 1895–97 *Solanum nigrum*, *Datura stramonium*, and *Atropa belladonna* became very abundant and aggressive on rich swampy lands and along the banks of water-races in several districts in the county. These dry years were succeeded by a wet and chilly period lasting to the present time, and these plants have consequently become rare. It would have been regrettable if these heat-loving but dangerous plants had become numerous in this extensive farming district. My observations on many species of naturalised plants during the last fifteen years has convinced me that their comparative habits in all seasons is a safe guide in tracing the source of their original home.

It may be of interest to botanists of the future to give brief notes on the condition of the naturalised flora of the county at the beginning of the twentieth century. Of the 368 species included in the following list—specimens of all having been collected in the county—95 per cent. belong to the Scandinavian flora; Australia is represented by 3 species, North Africa 1, South Africa 1, Asia 3, South America 3, and North America by 10 species.

The three Australian species are well dispersed over the hilly region of the county. *Vittadinia australis* and *Acæna ovina* are abundant on the hills and in the warmer inland valleys. The latter grows vigorously, and is becoming a great nuisance to sheep-owners by its burrs or seed-pods entangling in the wool. *Cotula australis* inhabits the warm valleys of the Gawler Downs, on the upper Hinds River.

The North African *Cytisus albidus* constituted for a de-

cade the chief undergrowth of the belt of trees extending along the railway-line for a considerable distance between Ashburton and Chertsey. Small areas of the white broom exist at present on the banks of the Ashburton River seawards of the town. The South African *Hibiscus trionum* I have thrice found in different localities, but it is nowhere numerous.

The Asiatic representatives include *Bidens pilosa*, *Nicandra physaloides*, and *Triticum sativum*. The two former were first discovered by Mr. Herring on the Alford Estate. The latter occurs in several localities.

The South American natives, *Oxalis rosea*, *Sisyrinchium striatum*, and *Solanum tuberosum*, occur on the river-bed as garden escapes.

The North American species, *Barbarea præcox*, *Limnanthus douglasii*, *Lupinus arboreus*, *Callomia coccinea*, *Mimulus luteus*, *M. moschætus*, *Ænothera stricta*, *Æ. biennis*, *Ribes sanguinea*, and *Pinus insignis*, are widely distributed over the county. *Mimulus luteus* grows luxuriantly in many creeks and swamps, while *M. moschætus*, the favourite musk, flourishes in large masses on the moist sandy and swampy flats. The two species of *Ænothera* are abundant on the Rakaia River flats, and annually produce a great display of their lemon-coloured flowers, which may be seen in passing over the river in the railway-train during the summer months. The seeds falling from the ripe cones of *Pinus insignis* grow freely, and they have grown into dense masses in some of the older plantations. The seed of *Ribes sanguinea* is carried by birds, and germinates from their excreta under trees where the birds roost. With the exception of *Pinus insignis*, the other species in this list are probably descendants from garden escapes many years ago.

The list of British and European species naturalised in the county include all the more valuable pasture-plants, comprising many grasses and clovers now forming the chief pastoral vegetation of the plains and up to several thousand feet on the subalpine ranges. In addition to many objectionable and injurious plants, they grow freely among the tussocks and snow-grasses (*Danthonia*) on the upland country. This class of mixed vegetation has added greatly to the value of pastoral runs during the last fifteen years, by enabling the owners to depasture larger flocks on them. Twenty years ago the common spear thistle (*Carduus lanceolatus*) invaded the hilly region of the county and caused great annoyance and loss to flock-owners, but it gradually decreased and became much less aggressive.

Unquestionably many species of naturalised plants occurring plentifully all over the county were early introductions.

Hypochæris radicata spread with great rapidity, and horehound (*Marrubium vulgare*) became established in large masses on every hill, knoll, and sunny slope where the flocks of sheep camped for the night, and around sheep farms and sheds where the flocks are shorn annually. Its prickly capsules are adapted for clinging to the wool of sheep and the fur of hares and rabbits—all having thus assisted to distribute them over the county.

The great impetus given to sheep-farming by the frozen-meat industry and the high prices ruling for cereals, together with the use of improved farming-implements and vastly improved methods of tillage, by utilising every available space of land, has greatly reduced the vast numbers of the less useful and injurious species of naturalised plants formerly abundant on many large areas of the plains. On the swampy parts and on the margins of the numerous water-races traversing the plains *Ranunculus sceleratus* grows luxuriantly in great profusion. In old pastures *R. repens* became very plentiful, especially on moist rich land; but it is now much reduced by frequent cultivation of the land for cropping. *Papaver rhœas* is less plentiful in cornfields than formerly, and *P. argemone* has made no progress during the last ten years. The latter only occurs in four districts in the county, and is a very objectionable plant in any pastoral country.

Many crucifers were early arrivals with the foul seed imported in the early days, and many species have spread and become naturalised throughout the county. *Brassica campestris* and *B. sinapistrum* have long been great scourges, and have in certain years taken almost complete possession of large cultivated areas. As already noted by Mr. Thomson,* the water-cress (*Nasturtium officinale*) grows in all the slow-flowing creeks and springs on the river-bed, and attains to proportions never previously observed in Europe.

The *Caryophylleæ* are largely represented. *Silene inflata*, *S. anglica*, *S. quinquevulnera*, *Lychnis vespertina*, *Spergula arvensis*, and *Arenaria serpyllifolia* flourish in conspicuous masses on both cultivated and uncultivated land. The fleshy rooted deep-rooting *S. inflata* and *L. vespertina*, when well established, cause hard work to plough-horses and expense to farmers in cropping their lands. *S. quinquevulnera* grows abundantly, and frequently produces large spikes of finely developed flowers with varying shades of colour.

The naturalised leguminous plants include some of the most aggressive. The gorse (*Ulex europæus*) and broom (*Cytisus scoparius*) occupy many thousand acres of the

* Trans. N.Z. Inst., vol. xxx., p. 313.

river-beds and by-roads of the plains, where their growth attains to great dimensions. In some districts they form extensive and impenetrable masses, and have proved good rabbit-warrens. The seed is carried by every water-race and every freshet and flood in the rivers and distributed over the country, and generally grows freely wherever it is deposited. When buried in the silt-beds deposited by the water-races the seed retains its vitality for an indefinite period. *Medicago denticulata*, the medick-burr, is less aggressive than formerly, though still unpleasantly plentiful. *Trifolium arvense* holds almost complete possession of dry, sandy, and stony situations, and covers many hundreds of acres of such areas in many parts of the county. It forms the chief vegetation growing on the stony slopes and terraces along the sea-coast during summer and autumn. An extensive area of poor land occupied with *T. arvense* in full bloom exhibits or assumes a marked feature of a desert vegetation. *Lotus corniculatus* flourishes in neat masses generally on poor land, but it is not plentiful, and disperses slowly.

The *Rosaceæ* comprise ten or more species. *Rubus fruticosus*, *Rosa rubiginosa*, *R. canina*, *Fragaria vesca*, and *Cratægus oxyacantha* have long been naturalised and widely dispersed by the agency of birds. The wild strawberry (*F. vesca*) is confined to the neighbourhood of the bush and moist warm valleys of the fore hills, and grows in extensive masses. *Prunus avium*(?) is also dispersing freely in old bush districts, and is doubtless the true species mentioned by De Candolle,* which does not produce suckers.

The stonecrop (*Sedum acre*) is the only representative of its order occurring in the county. It occurs in large patches on farms, and the means whereby it is distributed are not easily elucidated. I believe it to have been sown among unclean seed many years ago, and to have escaped notice until it grew into conspicuous masses during recent years.

The gooseberry (*Ribes grossularia*) has been distributed extensively by birds. The plants form miniature jungles in many old plantations where the introduced birds roost during the night.

In the *Umbelliferæ* the fennel (*Fœniculum vulgare*), the hemlock (*Conium maculatum*), and the wild carrot (*Daucus carota*) are the most regrettable introductions. The two former exist only in a few districts, while the latter covers many acres, and grows dense and strong, especially on neglected old roads and old pastures, and spreads rapidly.

Composites are largely represented, and comprise several almost valueless aud some destructive species. From the year

* "Origin of Cultivated Plants."

1880 to 1895, when the ruling prices for cereals and sheep were low, farmers remained somewhat inert, permitting their farms to be overrun with objectionable plants. During these years I observed the ox-eye daisy (*C. leucanthemum*), *C. segetum*, *Anthemis arvensis*, *Achillea millifolium*, *Convolvulus arvensis*, *Carduus arvensis*, *Onopordium acanthium*, *Crepis virens*, *Rumex acetosella*, and *Taraxacum dens-leonis* taking absolute possession of large and valuable paddocks that had been only once or twice ploughed. Needless to say, the cost of clearing the paddocks of these exotic plants within recent years has been prodigious. In wet seasons the daisy (*Bellis perennis*) blooms freely on the moist river-flats, but it fails to disperse and grow on drier land. *Senecio jacobæa*, which has taken possession of many square miles in Southland, occurs in isolated small patches near the hills, but it is rare on the open plains.

The introduced species of *Convolvulus* and the other allied plants listed are widely dispersed, and have proved destructive to cereal and clover crops. In 1893–94 the clover dodder (*Cuscuta europæa*) destroyed great quantities of red-clover (*Trifolium pratense*), but it has not been so destructive since those years. The great bind-weed (*Calystegia sepium*) has proved a great nuisance in some districts on good land, where it roots deeply and is difficult to eradicate. The common *Convolvulus arvensis* is the most widely dispersed species, and grows freely on almost any soil.

In the *Borragineæ*, *Echium vulgare* and *Lithospermum arvense* are the more widely distributed. The former, though producing tall well-developed spikes of ultramarine-blue flowers, is an objectionable plant to agriculturists. Nevertheless, a large group of these plants in full bloom is attractive and beautiful. The small-flowered *Myosotis arvensis* is abundant in many parts of the county, and grows freely in waste places, but more so on the moist margins of water-races or near swampy ground, where it produces neat spikes of its familiar flowers. *M. sylvatica* occurs in shady parts of the half-cleared bush at Mount Somers, but it is not yet abundant.

The *Scrophulariaceæ* comprise some old garden favourites which were early comers. Their occurrence on the ranges and in the inland valleys in the early years of settlement prove conclusively that they were not garden escapes. The hoary mullein (*Verbascum thapsus*) ascends to 5,000 ft. on the lower alps, and grows vigorously in large masses on the shingle slopes and sides of the valleys, producing a striking contrast to the stunted shrubby subalpine plants. The seed has undoubtedly been carried up the ranges in the wool of merino sheep. These animals, feeding among the plants in the autumn, when the seed is ripe, would shake it from the tall

seed-stems into their wool, and thus freely distribute it. When crossing the Ashburton moraine *en route* to the upper Rangitata in February last I observed *V. blattaria* and *V. phœniceum* growing among the tussocks and snow-grass. The foxglove (*Digitalis purpurea*) grows abundantly in some of the valleys, where its seed is probably distributed like that of *Verbascum*. *Veronica agrestis*, *serpyllifolia*, *arvensis*, *buxbaumii* are plentiful on waste places. The two additional species in the list are not anywhere numerous, and occur, when met with, in old pastures. *Bartsia viscosa* is one of the commonest of plants on the vast river-beds, where it frequently attains to 2 ft. in height, and produces large and well-developed spikes of its handsome yellow flowers.

The labiates include some rare and interesting and also some very aggressive plants. The spearmint (*Mentha viridis*) occurs in large masses on the sandy river-flats, and frequently overgrows damp ditches and water-races crossing the plains. *M. pulegium* is common on the margins of slow-flowing streams and stagnant lakes, and, like the spearmint, attains to height and vigour unknown in English gardens. *Prunella vulgaris*, *Melissa officinalis*, *Teucrium scorodonis*, *Stachys arvensis*, *S. germanica*, and *Lamium album* occur commonly in old pastures and among the general vegetation of the great river-flats.

The plantains are everywhere abundant. *Plantago major* displays greater vigour when growing on the cool shady side of plantations and on the margins of slow-flowing creeks. The other species occur largely in pastures and by damp hedgerows. *P. media* is seen at its best on slightly swampy but good land, where it grows in dense masses.

The species and varieties of *Chenopodium* are among the most worthless of naturalised plants. *C. album* and *urbicum* have, for thirty years, proved an unmitigated nuisance and expense to farmers in the county. They were the first English weeds to overrun the newly ploughed fields, where they grew and dispersed with great rapidity. Before the introduction of the modern seed-cleaning machinery it was almost impossible to keep the sacks of grain free from the weeds infesting the fields, and the two plants under notice were the worst of all. Like these plants, other tall-growing weeds were cut and bound up in the sheaves, and their seeds were thus freely distributed over farms. Sheep also greatly assisted by carrying the seed over the country in their wool.

From numerous inquiries among the very old colonists resident in the county I have ascertained that docks (*Rumex crispus*, *R. obtusifolius*) grew in masses in moist depressions in the Wakanui district before a plough had turned over a foot of the rich virgin land. Forty-four years ago there were

few or no fences on the plains, and merino sheep roamed free over the great expanse of tussocks. Every freshet in the natural water-channels where they grew would also rapidly distribute the seeds of these and other aggressive plants. Mr. John Cochrane informs me that he observed docks attain a height of 7 ft. in these channels in 1860; and the year following he observed the first thistles (*Carduus lanceolatus*) in Wakanui, and two years later they were plentiful on good land on the tussock plains. At that time they grew annually 3 or 4 acres of tobacco, which they cut three times in a season for sheep-dipping purposes. After the tussocks were burned they also sowed seed on the burned areas, which generally produced "more bad plants than good ones." The second year after ploughing the land sorrel (*Rumex acetosella*) spread over it, and soon took possession if not rigorously checked. Since tilling operations commenced about forty years ago sorrel has been a very aggressive and destructive pest. *Polygonum aviculare*, the so-called wire-weed, and the var. *Driandri*, are abundant everywhere. *P. minus*, *persicaria*, *convolvulus*, and *lapathifolium* attain to great perfection on the moist silty river-flats, and display a wealth of flowers during the autumn months.

When Mr. Cochrane arrived at the Wakanui sheep-station in 1860 nettles (*Urtica dioica*, *U. urens*) were growing about the sheep-yards erected a few years previously. They exist at present in a few hedgerows, but are not troublesome.

In wet seasons the seeds of *Betula alba*, *Populus alba*, *Salix fragilis*, *S. caprea*, and *Quercus robur* v. *pedunculata* produce seedlings in masses under old trees. The acorns of the oak have been carried by water-races and other streams crossing the plains and deposited in the silt, on which they grow into good-sized trees in a few years.

In the *Coniferæ*, *Pinus insignis*, *P. pinaster*, and *Cupressus macrocarpa* cast fertile seed and became naturalised fifteen years ago. There are other interesting aspects of the naturalisation of conifers that may be noted. Plants raised from seed of *C. macrocarpa* grown in the county lack the vigour and grow weaker, more narrow, and more upright than do those grown from imported seed. Notwithstanding that several species of *Abies*, *Picea*, and other conifers produce fertile cones and cast seed, I have not up to the present time observed any of them to grow and naturalise under the parent tree.

The banks of the north and south branches of the Ashburton River for many miles are overgrown with the weeping willow (*Salix babylonica*). The Wakanui Creek, from its intake to the sea, a distance of eleven miles, is also shaded by magnificent willows, all self-planted. During gales of

winds small twigs and limbs are broken from the older trees and float to and lodge on the banks, where they readily root and grow into large trees in a few years. When travelling through Wakanui across the open plain the irregular pale-green line of high beautiful willows produces an admirable contrast to the small plantations of sombre evergreen pines around the settlers' homes. From its artificial mode of dispersal and propagation I have not included this willow in my list of naturalised plants. The basket-willow (*S. rubra*) and the golden willow (*S. vitellina*) propagate likewise, but they are not so numerous as is the weeping willow.

As previously stated, several species of naturalised plants displayed great vigour and spread rapidly for a few years after their introduction, when their vigour declined and their numbers diminished and became rare or disappeared from large areas where formerly they were abundant. The disappearance of a large number of species is due to severe climatic conditions occurring at intervals of several years on the Canterbury Plains. The protracted drought between 1895 and 1898 very materially checked the progress and reduced the numbers of many species of naturalised plants in the county. Previous to those years large masses of buckwheat (*Fagopyrum esculentum*, Mœnch.) grew annually along the railway banks and sides, but I have not observed a single plant since the close of the drought. Several other species that were killed off certain areas by the drought have not up to the present time been able to re-establish themselves in the same numbers as formerly.

During the last five years of more or less cool wet weather at all seasons *Centaurea nigra* and *Onopordon acanthium* have dispersed rapidly. In the autumn, when the seed is ripe, the plants are visited by large flocks of goldfinches, who attack the flower-heads and scatter the seed in all directions. *Echium vulgare*, which is fertilised by humble-bees, is also increasing rapidly. *Diplotaxis muralis* and a tall-growing handsome-flowered *Nasturtium* which I have been unable to identify were first collected four years ago, but they now occur in several districts. Two plants of the teasel thistle (*Dipsacus sylvestris*) were sent to me last year from Waterton, but I have not collected it nor heard of its occurrence elsewhere in the county. The present great demand for all classes of arable land, and the extensive ploughing by improved methods proceeding annually, together with the use of strong artificial manures and vastly increasing flocks, will rapidly check and diminish the numbers of both native and naturalised plants excepting on waste places. A sketch of their introduction and progress in a given area during the last half-century will enable botanists of the future to note and

compare their numbers and development, which should be of great interest half a century hence. When the first colonists arrived the seasons continued for thirty years much more equable and genial than they have been during the remaining period. The land was rich and fresh, which enabled the newly introduced plants to attain to vigour and development probably never attained by previous generations of the species. During the last ten years many species have not displayed such vigour as formerly, such being probably due to the partial exhaustion of the soil, the modification of the climate under the changed vegetation, and the irruption of other species.

In recording these notes it is incumbent upon me to state that I have been for years greatly indebted to Mr. G. M. Thomson, F.L.S., for valued assistance in identifying many of the species for me. The late Professor T. Kirk, F.L.S., also very generously assisted in the identification of many species of grasses in the list. The late Mr. J. F. Armstrong and his son, Mr. J. B. Armstrong, likewise assisted in identifying and naming species submitted to them at different times after I began to study the naturalised plants some years ago. Mr. G. W. Leadley and Mr. C. Reid, former presidents of the Ashburton Agricultural and Pastoral Association, when in office did valuable service by urging the farmers of the county to collect exotic plants occurring on their farms and bring them to the rooms of the association. By this means I procured several interesting species which I had not previously collected. Of the deceased botanists I cherish thoughts of their kindness, while to those gentlemen who have assisted as stated I would here express sincere thanks.

Following is the list of plants collected :—

Ranunculaceæ.

Ranunculus acris, *L.*, Britain.
" sceleratus, *L.*, Britain.
" repens, *L.*, Britain.
" bulbosus, *L.*, Britain.
" arvensis, *L.*, Britain.
" parviflorus, *L.*, Britain.
Aconitum napellus, *L.*, Britain.
Aquilegia vulgaris, *L.*, Britain.
Delphinium ajacis, *Reichenbach*, Europe.

Papaveraceæ.

Papaver rhœas, *L.*, Britain.
" hybridum, *L.*, Britain.
" argemone.
Glaucium luteum, *L.*, Britain.
Chilidonium majus, *L.*, Britain.

CRUCIFERÆ.

Cheiranthus cheiri, *L.*, Britain.
Nasturtium palustre, *D.C.*, Britain.
" officinale, *L.*, Britain.
" *sp.*
Diplotaxis muralis.
Sisymbrium officinale, *L.*, Britain.
Barbarea præcox, *Br.*, North America.
" vulgaris, *Br.*, Britain.
Brassica oleracea, *L.*, Britain.
" napus, *L.*, Britain.
" alba, *Boiss.*, Britain.
" rapa, *L.*, Britain.
" sinapistrum, *Boiss.*, Britain.
" campestris, *L.*, Britain.
Sinapis nigra, *L.*, Britain.
" arvensis, *L.*, Britain.
Alyssum maritinum, *L.*, Europe.
" orientale, *Ard.*, Europe.
" calycinum, *L.*, Europe.
Arabis hirsuta, Br., Britain.
Cardamine hirsuta, *L.*, Britain.
Draba verna, *L.*, Britain.
Cochlearia armoracea, *L.*, Britain.
Raphanus sativus, *L.*, Britain.
Capsella bursa-pastoris, *L.*, Britain.
Senebiera coronopus, *Poiret*, Britain.
" didyma, *Persoon*, Britain.
Lepidium ruderale, *L.*, Britain.
" campestre, *Br.*, Britain.
Iberis amara, *L.*, Britain.

FUMARIACEÆ.

Fumaria officinalis, *L.*, Britain.
Corydalis lutea, *D.C.*, Britain.

RESEDACEÆ.

Reseda alba, *L.*, Britain.

VIOLACEÆ.

Viola tricolor, *L.*, Britain.
" odorata, *L.*, Britain.

CARYOPHYLLEÆ.

Dianthus barbatus, *L.*, Europe.
" armeria, *L.*, Britain.
" prolifer, *L.*, Britain.
Saponaria officinalis, *L.*, Britain.
Silene inflata, *Smith*, Britain.

Silene nutans, *L.*, Britain.
„ anglica, *L.*, Britain.
„ quinquevulnera, *L.*, Britain.
„ noctiflora, *L.*, Britain.
Lychnis diurna, *Sibthorpe*, Britain.
„ vespertina, *Sibthorpe*, Britain.
„ githago, *Lamarck*, Britain.
„ flos-cuculi, *L.*, Britain.
Sagina procumbens, *L.*, Britain.
Gypsophylla tuberosa, *Boisier*, Britain.
Stellaria media, *Witherington*, Britain.
„ holostea, *L.*, Britain.
„ graminea, *L.*, Britain.
Cerastium vulgatum, *L.*, Britain.
„ arvense, *L.*, Britain.
„ triviale, *Link*, Britain.
Polycarpon tetraphyllum, *L.*, Britain.
Spergula arvensis, *L.*, Britain.
Arenaria serpyllifolia, *L.*, Britain.
Spergularia rubra, *Persoon*, Britain.

Hypericineæ.

Hypericum androsæmum, *L.*, Britain.
„ perforatum, *L.*
„ calycinum, *L.*, Britain.
„ montanum, *L.*, Britain.

Lineæ.

Linum usitatissimum, *L.*, Britain.
„ catharticum, *L.*, Britain.

Malvaceæ.

Hibiscus trionum, *L.*, South Africa.
Lavatera arborea, *L.*, Britain.
Malva moschæta, *L.*, Britain.
„ rotundifolia, *L.*, Britain.
„ sylvestris, *L.*, Britain.
„ verticillata, Britain.
Althea officinalis, *L.*, Britain.

Geraniaceæ.

Geranium dissectum, *L* , Britain.
„ robertianum, *L.*, Britain.
„ lucidum, *L.*, Britain.
„ molle, *L.*, Britain.
Erodium cicutarium, *L. Heritier*, Britain.
„ moschatum, *L. Heritier*, Britain.
Oxalis corniculata, *L.*, Britain.
„ rosea, *Jacquin*, South America.
Limnanthus douglasii, North America.

LEGUMINOSÆ.

Cytisus scoparius, *L.*, Britain.
„ albidus, *L.*, North Africa.
Ulex europæus, *L.*, Britain.
Medicago sativa, *L.*, Britain.
„ lupulina, *L.*, Britain.
„ denticulata, *Wildenow*, Britain.
Melilotus alba, *Lamarck*, Britain.
„ officinalis, *L.*, Britain.
Trifolium incarnatum, *L.*, Britain.
„ medium, *L.*, Britain.
„ arvense, *L.*, Britain.
„ hybridum, *L.*, Britain.
„ ochroleucum, *L.*, Britain.
„ pratense, *L.*, Britain.
„ glomeratum, *L.*, Britain.
„ repens, *L.*, Britain.
„ procumbens, *L.*, Britain.
„ minus, *Sm.*, Britain.
Lathyrus nissolia, *L.*, Britain.
„ pratensis, *L.*, Britain.
Lotus corniculatus, *L.*, Britain.
Onobrychus sativa, *Lamarck*, Britain.
Vicia hirsuta, *Koch*, Britain.
„ tetrasperma, *Mœnch.*, Britain.
„ lutea, *L.*, Britain.
„ sativa, *L.*, Britain.
Lupinus arboreus, *Sims*, North America.
„ luteus, *L.*, Europe.
Viburnum vulgaris, *L.*, Europe.

ROSACEÆ.

Agrimonia eupatoria, *L.*, Britain.
Potentilla anserina, *L.*, Britain.
Rubus fruticosus, *L.*, Britain.
„ idaeus, *L.*, Britain.
Rosa canina, *L.*, Britain.
„ rubiginosa, *L.*, Britain.
Prunus avium(?), *L.*, Britain.
Fragaria vesca, *L.*, Britain.
Cratægas oxyacantha, *L.*, Britain.
Acæna ovina, *Cunn.*, Australia.

ONOGRAREÆ.

Ænothera biennis, North America.
„ stricta, North America.

LYTHRACEÆ.

Lythrum hyssopifolium, *L.*, Britain.

Portulaceæ.

Portulaca oleracea, *L.*, Europe.

Crassulaceæ.

Sedum acre, *L.*, Britain.

Ribesiaceæ.

Ribes grossularia, *L.*, Britain.
" sanguinea, *Purch*, North America.

Umbelliferæ.

Hydrocotyle vulgaris, *L.*, Britain.
Apium graveolens, *L.*, Britain.
Petroselinum sativum, *Hoffnau*, Britain.
Fœniculum vulgaris, *Gærtner*, Britain.
Pastinacea sativa, *L.*, Britain.
Scandix pecten-veneris, *L.*, Britain.
Daucus carota, *L.*, Britain.
Conium maculatum, *L.*, Britain.

Caprifoliaceæ.

Sambucus nigra, *L.*, Britain.

Rubiaceæ.

Gallium aparine, *L.*, Britain.
" palustre, *L.*, Britain.
Sherardia arvensis, *L.*, Britain.

Valerianeæ.

Centranthus ruber, *D.C.*, Europe.

Compositæ.

Conyza ambigua, *D.C.*, Europe.
Petasites vulgaris, Europe.
Erigeron canadensis, *L.*, Britain.
Vittadinia australis, *A. Rich.*, Australia.
Bellis perennis, *L.*, Britain.
Chrysanthemum segetum, *L.*, Britain.
" leucanthemum, *L.*, Britain.
" partheuium, *Persoon*, Britain.
Matricaria chamomilla, *L.*, Britain.
Anthemis arvensis, *L.*, Britain.
Calendula officinalis, *L.*, Europe.
Achillea millefolium, *L.*, Britain.
Tanacetum vulgare, *L.*, Britain.
Artemisia absinthium, *L.*, Britain.
Gnaphalium luteo-album, *L.*, Britain.
" germanicum, *Wildenow*, Britain
Senecio vulgaris, *L.*, Britain.

Senecio sylvaticus, *L.*, Britain.
„ jacobæa, *L.*, Britain.
Bidens pilosa, *L.*, Western Asia.
Arctium lappa, *L.*, Europe.
Cotula australis, *Hooker*, Australia.
Carduus marianus, *L.*, Britain.
„ lanceolata, *L.*, Britain.
„ arvensis, *Curtis*, Britain.
„ pycnocephalus, *Jacquin*, Britain.
Onopordium acanthium, *L.*, Britain.
Centaurea nigra, *L.*, Britain.
„ cyanus, *L.*, Britain.
„ calcitrapa, *L.*, Britain.
„ solstitialis, *L.*, Britain.
Tragopogon pratense, *L.*, Britain.
Picris hieracioides, *L.*, Britain.
Leontodon hirtus, *L.*, Britain.
„ autumnalis, *L.*, Britain.
Hypochœris glabra, *L.*, Britain.
„ radicata, *L.*, Britain.
Sonchus arvensis, *L.*, Britain.
„ oleraceus, *L.*, Britain.
„ asper, *Hoffman*, Britain.
Taraxacum dens-leonis, *Desfontaine*, Britain.
Crepis virens, *L.*, Britain.
Cichorium intybus, *L.*, Britain.
Lapsana communis, *L.*, Britain.

Campanulaceæ.

Campanula hybrida, *L.*, Britain.

Primulaceæ.

Primula vulgaris, *L.*, Britain.
„ polyanthus, *L.*, Britain.
Anagallis arvensis, *L.*, Britain.
„ cerulea, *L.*, Britain.

Jasmineæ.

Fraxinus excelsior, *L.*, Britain.

Apocynaceæ.

Vinca major, *L.*, Britain.
„ minor, *L.*, Britain.

Gentianeæ.

Erythræa centaurium, *Persoon*, Britain.

Polymoniaceæ.

Gilia cerulea.
Collomia coccinea, *Lehman*, North America.

Convolvulaceæ.

Convolvulus arvensis, *L.*, Britain.
" sepium, *R. Br.*, Britain.
" " *v.* sylvatica, Europe.
Cuscuta trifolii, *Babington*, Britain.
" europæa, *L.*, Britain.

Boragineæ.

Echium vulgare, *L.*, Britain.
" violaceum, *L.*, Britain.
Lithospermum arvense, *L.*, Britain.
Anchusa officinalis, *L.*, Britain.
Myosotis palustris, *Witheringtón*, Britain.
" sylvatica, *Hoffman*, Britain.
" arvensis, *Roth*, Britain.
Lycopsis arvensis, *L.*, Britain.
Borago officinalis, *L.*, Britain.
Cynoglossum furcatum, *Wall*, Europe.

Solanaceæ.

Solanum nigrum, *L.*, Britain.
" tuberosum, *L.*, South America.
Nicandra physaloides, *Gærtner*, Western Asia.
Datura stramonium, *L.*, Britain.
Atropa belladonna, *L.*, Britain.
Lycium barbatum, *L.*, Britain.

Scrophulariaceæ.

Verbascum thapsus, *L.*, Europe.
" blattaria, *L.*, Europe.
" phœniceum, *L.*, Europe.
Linaria vulgaris, *Mœnchner*, Europe.
" elatine, *Desfontaine*, Europe.
" purpurea, *Miller*, Europe.
" cymbalaria, *Miller*, Britain.
Scrophularia aquatica, *L.*, Britain.
Mimulus luteus, *Wildenow*, North America.
" moschatus, *Douglas*, North America.
Digitalis purpurea, *L.*, Britain.
Veronica agrestis, *L.*, Britain.
" serpyllifolia, *L.*, Britain.
" buxbaumii, *Tenare*, Britain.
" arvensis, *L.*, Britain.
" officinalis, *L.*, Britain.
Bartsia viscosa, *L.*, Britain.

LABIATÆ.

Mentha viridis, *L.*, Britain.
„ pulegium, *L.*, Britain.
Prunella vulgaris, *L.*, Britain.
Mellisa officinalis, *L.*, Britain.
Marrubiumv ulgare, *L.*, Britain.
Stachys arvensis, *L.*, Britain.
„ germanica, *L.*, Britain.
„ annua.
Lamium purpureum, *L.*, Britain.
„ album, *L.*, Britain.
Teucrium scorodonis, *L.*, Britain.

VERBENACEÆ.

Verbena officinalis, *L.*, Britain.

PLANTAGINEÆ.

Plantago major, *L.*, Britain.
„ media, *L.*, Britain.
„ lanceolata, *L.*, Britain.
„ coronopus, *L.*, Britain.

CHENOPODIACEÆ.

Chenopodium album, *L.*, Britain.
„ *v.* glabrum, Britain.
„ *v.* viride, Britain.
„ rubrum, *L.*, Britain.
„ urbicum, *L.*, Britain.
Atriplex patula, *L.*, Britain.
„ *varieties.*

POLYGONEÆ.

Rumex crispus, *L.*, Britain.
„ obtusifolius, *L.*, Britain.
„ pulcher, *L.*, Britain.
„ acetosa, *L.*, Britain.
„ acetosella, *L.*, Britain.
Polygonum aviculare, *L.*, Britain.
„ *v.* dryandri, Britain.
„ minus, *Hudson*, Britain.
„ persicaria, *L.*, Britain.
„ convolvulus, *L.*, Britain.
„ lapathifolium, *L.*, Britain.

EUPHORBIACEÆ.

Euphorbia peplus, *L.*, Britain.
„ lathyris, *L.*, Britain.
„ helioscopia, *L.*, Britain.
Mercurialis annua, *L.*, Britain.

Urticeæ.

Urtica urens, *L.*, Britain.
" dioica, *L.*, Britain.

Aceraceæ.

Acer campestre.

Amentaceæ.

Salix fragilis, *L.*, Britain.
Betula alba, *L.*, Britain.
Populus alba, *L.*, Britain.
Quercus robur, *L.*, Britain.
" *v.* pedunculata, *L.*, Britain.

Coniferæ.

Pinus insignis.
" pinaster, Europe.

Typhaceæ.

Sparganium simplex, *Hudson*, Britain.

Irideæ.

Sisyrinchium striatum, *Cavanilles*, South America.

Liliaceæ.

Asparagus officinalis, *L.*, Europe.

Juncaceæ.

Juncus bufonius, Britain.

Gramineæ.

Millium effusum, *L.*, Britain.
Digitaria sanguinale, *Scopoli*, Britain.
Sclavia verticillata, *Palisot*, Britain.
" glauca, *Palisot*, Britain.
Anthoxanthum odoratum, *L.*, Britain.
Phalaris canariensis, *L.*, Britain.
Phleum pratense, *L.*, Britain.
" arenarium, *L.*, Britain.
Alopecurus agrestis, *L.*, Britain.
" pratensis, *L.*, Britain.
" geniculatus, *L.*, Britain.
Lagurus ovatus, *L.*, Britain.
Polypogon monspeliensis, *Desf.*, Britain.
" littoralis, *Sm.*, Britain.
Agrostis alba, *L.*, Britain.
" *v.* stolonifera, Britain.
" *v.* vulgaris, Britain.

Agrostis canina, *L.*, Britain.
Psamma arenaria, *Palisot*, Europe.
Aira caryophyllea, *L.*, Britain.
„ flexuosa, *L.*, Britain.
Avena pubescens, *L.*, Britain.
„ elatior, *L.*, Britain.
„ fatua, *L.*, Britain.
Trisetum flavescens, *Palisot*, Europe.
Archenatherum avenaceum, *Palisot*, Britain.
„ *v.* bulbosum, Britain.
Holcus mollis, *L.*, Britain.
„ lanatus, *L.*, Britain.
Cynodon dactylon, *Persoon*, Britain.
Nardus stricta, *L.*, Britain.
Elymus arenarius, *L.*, Britain.
Hordeum murinum, *L.*, Britain.
„ sativum, *Hudson*, Britain.
Triticum repens, *L.*, Britain.
„ sativum, *L.*, Asia.
„ caninum, *Hudson*, Britain.
„ junceum(?), *L.*, Britain.
Lolium perenne, *L.*, Britain.
„ temulentum, *L.*, Britain.
Brachypodium sylvaticum, *Palisot*, Britain.
Bromus sterilis, *L.*, Britain.
„ mollis, *L.*, Britain.
„ racemosus, *L.*, Britain.
„ arvensis, *L.*, Britain.
„ matritensis, *L.*, Britain.
„ erectus, *Hudson*, Britain.
„ secalinus(?) *Hudson*, Britain.
Festuca ovina, *L.*, Britain.
„ *v.* rubra, Britain.
„ *v.* duriuscula, Britain.
„ elatior, Britain.
„ *v.* pratensis, Britain.
„ *v.* loliacea, Britain.
Dactylis glomerata, *L.*, Britain.
Melica nutans, *L.*, Britain.
Cynosurus cristatus, *L.*, Britain.
Briza media, *L.*, Britain.
„ minor, *L.*, Britain.
„ maxima, *L.*, Europe.
Poa procumbens, *Curtis*, Britain.
„ annua, *L.*, Britain.
„ rigida, *L.*, Britain.
„ pratensis, *L.*, Britain.
„ nemoralis, *L.*, Britain.

Poa trivialis, *L.*, Britain.
Glyceria aquatica, *Sm.*, Britain.
„ fluitans, *R. Br.*, Britain.
„ maritima, *Sm.*, Britain.

Since the foregoing was written I have collected the undernoted species, some of which have been identified by Professor Cheeseman, F.L.S., and Mr. G. M. Thomson, F.L.S. *Pyrus aucuparia* was inadvertently omitted from the above list.

Salsola kali.
Silene armeria.
Dipsacus sylvestris.
Lepidium draba.
Cynara cardunculus.
Hieracium subaudum.
Crepis taraxifolia.

Art. XXVI. — *A Botanical Excursion during Midwinter to the Southern Islands of New Zealand.*

By L. Cockayne, Ph.D.

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Introduction.

The Southern Islands of New Zealand consist of several groups of small islands — namely, the Snares, Auckland Islands, Campbell Island, Macquarie Island, Antipodes Islands, and Bounty Islands—lying in the South Pacific Ocean between the parallels of 54° 44′ and 47° 43′ south latitude and 159° 49′ and 179° east longitude. The distance and direction of each of these groups from the South Cape of Stewart Island is respectively: The Snares, 60 miles S.W.; the Auckland Group, 190 miles S. by W.; Campbell Island, 330 miles S. by E.; Macquarie Island, 570 miles S.W. by S.; the Antipodes Islands, 490 miles E.S.E.; the Bounty Islands, 490 miles E.

As is well known, these Southern Islands of New Zealand form a part of that ring of small islands which stretch right round the globe between the parallels of 45° and 65° south latitude, frequently at very great distances from one another, but which nevertheless have certain Fuegian* species of plants in common. Of these latter, the Southern Islands of New Zealand possess by far the smallest share, their flora as a whole being very closely allied to that of New Zealand. This latter extremely important fact was discovered by Sir Joseph Hooker, who on that account separated the islands lying to the south of New Zealand from the other so-called "Antarctic islands," and devoted the first volume of his magnificent "Flora Antarctica" (46) to their botany. This work, published in 1847, was the outcome of collections and observations made by the distinguished author himself, assisted by Mr. Lyall, during the stay of about one month in Auckland and Campbell Islands (19th November to 17th December, 1840) of the Antarctic expedition commanded by Sir James Ross (91). Prior to this—in the previous year, indeed—the Auckland Islands had been visited by two other scientific expeditions—the French Antarctic expedition under Admiral D'Urville and the American Wilkes expedition. Of these two, the French was by far the most important from the botanical point of view: the collections were large, although not nearly equal in extent to those of Hooker; while, on the other hand, the American expedition did little botanically. Had this latter, as originally intended, been accompanied by Asa Gray the botanical results would doubtless have been very different, but owing to the many delays hindering the expedition setting forth the great American botanist finally declined to accompany it (25).

The botanical collections of the French expedition were made in part by MM. Hombron and Jacquinot and in part by the

* For explanation of the term "Fuegian," see "History of the Flora," further on.

admiral himself. In all 269 species were collected, of which twenty-one were spermaphytes or pteridophytes. These were published in 1852 as a part of the great work "Voyage au Pole Sud," a splendid folio volume (44), containing figures of the different species and names given by Hombron and Jacquinot, but without descriptions. The text was published separately, Tom. I., in 1845, containing descriptions of the *Muscineæ* and *Thallophyta* by M. C. Montagne (78), and Tom. II., in 1852, containing descriptions of the vascular plants by M. J. Decaisne (26). This latter author changed some of Hombron and Jacquinot's names, as they were not in accordance with the rules for botanical nomenclature. Between the publication of the "Flora Antarctica" and the "Handbook of the New Zealand Flora" a few additions to the flora of the Auckland Group were made by General Bolton, and such appear in the Handbook.

In November, 1880, Dr. J. H. Scott paid a visit to Macquarie Island, the flora of which was known only from a small collection of plants, seven in number, sent many years previously to Sir W. Hooker by Mr. Fraser, of Sydney. Scott published his results in a very valuable paper (93) which appeared in the "Transactions of the New Zealand Institute" for 1883, from which a good idea of the physiognomy of the vegetation may be obtained. His collection numbered 16 spermaphytes, 3 pteridophytes, 8 musci, 7 lichens, and 6 fungi—40 species in all. "I was there in November," he writes (93, p. 487), "and in these latitudes spring is but little advanced in that month. I therefore found comparatively few plants in flower. This, of course, has added much to the difficulty of identifying my specimens, and, combined with the thick weather, has helped to make my collection smaller than it might have been under more favourable circumstances."

In December, 1883, Mr. J. Buchanan visited Campbell Island in order to procure a collection of living plants for the various botanical gardens of New Zealand and an herbarium collection for the Colonial Museum, Wellington. He published his results in a short paper, two pages only, in the "Transactions of the New Zealand Institute," 1884 (9), publishing a new species of *Pleurophyllum (P. hookeri)* in the same volume (10). The former of these papers also contains some interesting drawings of the coast of Campbell Island.

In the summer of 1890 Mr. T. Kirk visited the whole of the Southern Islands, excepting Macquarie Island, and was in consequence able to publish an account of the botany of the Snares and Antipodes Islands for the first time—a much-needed and most valuable work. He also dealt with the botany of the Auckland Group and Campbell Island, and summed up what was known regarding the flora of Macquarie Island.

His papers on the different islands appeared in various publications mentioned in the bibliography; but they are all virtually the same, and appear all together in the Report of the Australasian Association for the Advancement of Science for 1891 (56). Mr. F. R. Chapman, now Mr. Justice Chapman, visited the islands at the same time as Kirk, and his paper entitled "The Outlying Islands south of New Zealand," though published amongst the miscellaneous papers in the "Transactions of the New Zealand Institute," 1891, is a very valuable contribution to botany (16).

Mr. H. J. Matthews, now Chief Government Forester, in 1895 made a very extensive collection of living plants from the various islands, and, I understand, succeeded in sending a large number to the Royal Botanic Gardens, Kew, in excellent condition. Moreover, he has cultivated for many years a large percentage of the Southern Islands' plants with success, a matter by no means easy.

Macquarie Island was examined botanically a second time by Mr. A. Hamilton in the summer of 1894. He added fourteen species to the list of Macquarie Island plants, bringing up the number of spermaphytes and pteridophytes to thirty species, if those which are doubtful in Scott's list be eliminated. According to Hamilton (39) the island is entirely without trees: "there is not a shrub or plant large enough to make a penholder." "The large *Poa* tussocks are the great feature of the low levels, and on the hill-tops the special feature is the *Azorella*, forming bright-green closely growing convex masses of stems and leaves." *Coprosma repens* and *Polypodium australe pumila* grow on the *Azorella* cushions. Between the tussock-belt and the *Azorella* is a zone of *Stilbocarpa polaris* and *Pleurophyllum hookeri*.

What is known about the geology of the islands is the outcome of collections made by Mr. H. Armstrong in 1868 and Mr. J. H. Baker in 1865, of a lengthy stay on Campbell Island by the French Transit of Venus Expedition in 1874, and of a visit paid to the various islands by Sir James Hector during a trip of the "Hinemoa" in 1895.

Besides scientific expeditions, even from the time of their discovery, the various islands have been visited by whaling-ships, by sealing expeditions, and by vessels sent for the purpose of looking for castaways. This latter has arisen from the number of disastrous wrecks which have taken place in the Southern Islands, especially in the Auckland Group. Of these, one especially concerns us here, that of the "Grafton," details of which are given below when treating of Auckland Island. This wreck led to the brig "Amherst" being sent to examine all the islands for castaways in 1868, and in his report (2) Mr. H. Armstrong published for the first time some informa-

tion regarding the plants of the Snares and Antipodes Islands, using certain Maori or colonial names for the plants. Amongst others, he stated that there was abundance of the "McQuarrie cabbage"—"of fine growth, the leaves measuring two feet in diameter." Now, the above name is also given to *Myosotidium nobile*, of Chatham Island, and this has led to a curious mistake, for it was concluded that this latter plant was the one in question. Hence arose the statement that *Myosotidium* occurred both on the Snares and Chatham Island, a somewhat remarkable distribution had it been so. Kirk,* *e.g.*, described *Myosotidium* as abundant on the Snares, and this most pardonable error has been copied into all works on general plant-geography. In 1865 the Victorian Government s.s. "Victoria," commanded by Captain Norman, visited the Auckland, Campbell, and Antipodes Islands, landing various domestic animals and planting certain trees, details regarding which are given further on. Finally, provision-depots and boat-sheds were erected for the use of castaways by the New Zealand Government. In connection with these depots the "Hinemoa" or some other boat visits all the islands, excepting Macquarie, twice a year, this latter, although biologically, yet not politically belonging to New Zealand. The depots were built at different times. Captain Bollons writes to me, "Provisions were left in various places in cases as early as 1865, but the present boat-sheds and depots date from 1887." In connection with these depots cattle, sheep, and goats have been landed from time to time, and seeds of exotic plants sown, both most important matters for the indigenous vegetation. More important still was the Enderby Settlement in the year 1850, which lasted for three years, during which time three hundred people resided in the north of Auckland Island and on Enderby Island. Then many domestic animals were introduced, portions of the forest were cleared, grasses were sown, and gardens made. But by far the most important event, so far as the plant-life is concerned, has been the establishing a sheep-run on Campbell Island in 1896, the effect of which upon the vegetation is described at some length further on.

Up to the time of my visit all the botanical observations in the Southern Islands had been made in spring or summer. It was therefore with very great pleasure that I joined the "Hinemoa" at Lyttelton in the middle of June, 1903, for the purpose of making a winter botanical excursion to the islands, the winter aspect of the vegetation as a whole being undescribed and, so far as the endemic plants were concerned, unknown.

* Trans. N.Z. Inst., vol. x., p. 410. 1878.

Unfortunately, although we waited some days at Port Pegasus, in Stewart Island, for favourable weather, the sea at the Snares was altogether too rough to allow a landing to be attempted; but, with the exception of Macquarie Island, I visited portions of all the other islands. Interesting as a visit in midwinter is, the days are so short, the number of places to be visited by the steamer so many, and the time which can be spared for the excursion as a whole so limited, that in nearly every instance only a quite cursory examination of the plant-formations and of their members was possible. All the work, moreover, under such circumstances had to be done in feverish haste, for in a given number of all-too-short hours, or even minutes in some instances, notes had to be written, perhaps with numbed fingers or in a driving mist, photographs hastily taken, plants both for drying and cultivation collected, while in many places the country to be traversed was of extreme difficulty. If under such circumstances errors creep into one's work, or if many important observations are neglected, it is perhaps not to be wondered at. In some instances, chiefly with regard to grasses, it has been impossible to identify my specimens. On Campbell Island, owing to the density of the scrub, I found it quite impossible to make any headway burdened with a heavy bag of plants. Night was coming on, and to my intense regret I had to throw away nearly the whole of the plants collected on Lyall's Pyramid. Much of the work in this paper is preliminary and provisional, but it may perhaps lead to a more thorough treatment before long of the vegetation of this, the most interesting region in the New Zealand biological area. The plant-formations are the edaphic formations of Schimper, but their limits as defined by me are far from satisfactory. In some few instances I have distinguished the smaller groups in a formation under the term "plant-association," meaning by this a small collection of two or more plants which usually occur associated together, and which I agree with Kearney* and Ganong† in considering a distinct ecological conception.

In what follows, the term "New Zealand biological region" includes the Kermadec Islands, the North and South Islands of New Zealand and their adjacent small islands, Stewart Island, the Chatham Islands, and the Southern Islands; while by "New Zealand" is meant the North and South Islands of New Zealand, Stewart Island, and the adjacent small islands.

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* "Report on a Botanical Survey of the Dismal Swamp Region," Contr. from the Nat. Herb., vol. v., No. 6, p. 359. Washington, 1901.

† "The Vegetation of the Bay of Fundy Salt and Diked Marshes," Bot. Gaz., vol. xxxvi., p. 301. 1903.

Before concluding this introduction I must offer my most sincere thanks to the Hon. W. Hall-Jones, M.H.R., Minister of Marine, for affording me facilities to visit the Southern Islands. Also, I must express my great obligation to the following for most valuable assistance in many ways: Professor Charles Chilton, D.Sc.; Mr. George Laurenson, M.H.R.; Mr. R. Speight, M.A., B.Sc.; Mr. D. Petrie, M.A.; Mr. H. Woods; Mr. W. Joss; and Mr. J. Gordon. Finally, I am bound to express my gratitude to Captain J. Bollons, of the Government s.s. "Hinemoa," who did all in his power to assist my work, and who, in addition, has given me much valuable information regarding the Southern Islands.

I. The Auckland Islands.

General remarks.

The Auckland Islands lie between the parallels of about 50° 30′ and 50° 55′ south latitude and the meridians of 165° 55′ and 166° 20′ east longitude (90, p. 405). They were discovered by Captain Abraham Bristow on the 18th August, 1806, during a whaling voyage in the ship "Ocean," a vessel belonging to Mr. Samuel Enderby. The group was named by its discoverer after Lord Auckland. In 1807 Captain Bristow visited the islands for a second time, and on that occasion took formal possession of the group.

Since its discovery, the Auckland Island Group has been repeatedly visited by sealers and whalers, the former having lived for months at a time on the main island, and made tracks across the mountains to the "seal-rookeries." During the years 1839–40 three scientific expeditions visited the northern part of the group, the botanical results of which have been already dealt with. In the year 1850 the Messrs. Enderby made the Auckland Islands the headquarters of the Southern Whale-fishery Company (31), the islands "having been granted by Her Majesty's Government" [so runs the prospectus of the company] "to Mr. Enderby and two of his brothers." Accordingly Mr. C. Enderby formed a settlement, consisting of three hundred Europeans and Maoris, in the neighbourhood of Port Ross; but the company was not successful, and after three years the settlement was abandoned. Shortly before the Enderby Settlement a number of Maoris from Chatham Island had taken up their abode in the north of Auckland Island, but these also did not stay long. During the Enderby Settlement a considerable piece of forest was cleared. This clearing is referred to later on.

Since the Auckland Islands lie in the direct route of sailing-vessels to Cape Horn it is not surprising that several disastrous shipwrecks have taken place. These led to the

New Zealand Government erecting depots for castaways in several parts of the group, and boat-sheds on some of the smaller islands. Thus, there are now provision-depots and boat-sheds at Port Ross, in the north of the main island; at the head of Norman Inlet; and at Camp Cove, Carnley Harbour; while on Enderby Island, Rose Island, and Ewing Island are boat-sheds, boats, and a small quantity of food. At the beginning of January, 1863, the "Grafton," a small schooner of 75 tons (83, p. 37), engaged in sealing, was wrecked, as stated in the introduction, in Carnley Harbour. The officers and crew, five in all, landed safely, and lived in the south of Auckland Island for more than a year and a half. Finally they managed to patch up the dingey, and in this frail craft Captain Musgrave, Mr. F. E. Raynal, the mate, and one of the crew reached Stewart Island. The remainder of the crew, two in number, were subsequently rescued by the "Flying Scud," the cost of the rescue expedition being met by public subscription from the people of Invercargill (83, p. 98). Both Musgrave (83) and Raynal (87) wrote an account of their sojourn on the island, and Musgrave's is of distinct scientific value, since he kept, with more or less regularity, a record of the climate. The botanical history of the Auckland Islands has been dealt with in the introduction, so no more need be said on that head.

PHYSIOGRAPHY.

The Auckland Islands consist of one large island, Auckland Island, and several smaller ones separated from the main island by more or less narrow channels. The entire group is some twenty-seven miles in length by fifteen miles in breadth. The shape and relative size of the various islands may be seen from the accompanying map (Pl. XXIII.), and an excellent idea of the coast-line is afforded by the sketches of headlands and harbours of the Auckland Islands made to accompany a map by officers of H.M.S. "Blanche" in 1870, and reproduced on a smaller scale in plates Nos. 47–49 accompanying Chapman's paper (16). Auckland Island, Adams Island, and Disappointment Island are extremely hilly; indeed, Adams Island consists entirely of a ridge 609m. in height, its southern cliffs rising abruptly out of the sea, but its northern side consisting of long spurs sloping towards Carnley Harbour. The hills of Auckland Island vary from 280m., the height of the Hooker Hills in the north, to summits reaching to 457m. or more in the south. Seen from the sea, on the north and eastern sides are long grassy slopes of no great steepness, very similar in appearance to those of Banks Peninsula, in the South Island of New Zealand. In the south the hills are rather more abrupt. The whole of the western side of the main island consists of

a precipitous wall of cliffs varying from 60m. to 243m. in height, and which can be climbed with extreme difficulty, according to Mr. W. Joss, in one or two places. The eastern coast, on the contrary, is deeply cut into by numerous inlets, resembling the west coast sounds of the South Island of New Zealand in miniature. Norman's Inlet, the most southerly of any size, and the largest, penetrates into the island for a distance of about six miles. Port Ross, in the north, and the North Arm of Carnley Harbour, in the south, also extend for about a similar distance inland. This irregularity of the eastern seaboard is of considerable phytogeographical importance, since it leads to an extensive coast-line, and to many stations differing considerably with regard to exposure to sun and wind. The numerous gullies which lie between the spurs of the hills or seam the hillside contain streams of considerable size if the small extent of land-surface of the island be considered. Enderby Island, Ewing Island, and Rose Island are flat or undulating, but they also have many coastal cliffs. Disappointment Island is high land clad with meadow and low forest or scrub. It has never been visited botanically.

GEOLOGY.

The following is extracted from a paper by Sir James Hector entitled "Note on the Geology of the Outlying Islands of New Zealand," (41) which contains the results of his observations made during the visit to the Southern Islands in 1895 mentioned in my introduction: "Auckland Island is clearly connected with the Snares by a ridge or plateau, the soundings ranging from 86 fathoms to 196 fathoms only. So far as seen Auckland Island is altogether volcanic, and closely resembles the rock-structure of Banks Peninsula." "Along the east coast there is a succession of harbours or inlets like those in Banks Peninsula, the steep shores of which are formed of successive sheets of basaltic lava often columnar and varying from 10 ft. to 80 ft. in thickness. These are separated by brightly coloured layers of volcanic tufa or ashes containing blocks of all sizes." "Disappointment Island is probably a 'neck' or 'dyke' through which some of the igneous rocks have been extruded." "The south side of Adams Island is the most exposed part of the Aucklands, and presents cliffs composed, as exposed in sections, of horizontal layers of basalt and tufa to a height of 1,900 ft., some of the cliffs being 1,400 ft. sheer down. The lava-sheets vary in thickness from 10 ft. to 80 ft., and there is evidence of not less than seventy distinct outpourings still preserved above the sea-level. Soundings three miles off shore from the South Cape gave 95 fathoms (575 ft.). The average dip of the lava-flows to the eastward is 7°. The width of the island in this

section is ten miles and the height of the western cliffs 1,000 ft.; so that by adopting the usually accepted curve for volcanic deposits we have the following result: Auckland Island is the remnant of a great volcanic cone that was 12,000 ft. in height and 50 miles in diameter in early Tertiary times, the chief centre having been about eight miles west of Disappointment Island. Four-fifths of the original mass has been removed by the denuding force of the westerly waves."

CLIMATE.

"The temperature is very equable," writes Mr. C. Enderby, "the snow never lying more than three days on the ground, except on the summit of the hills. The winds are violent and of long duration; the gales are mostly from the north-west, although I experienced two from the eastward unusually strong. They mostly commence at north with a falling barometer, veer gradually to west and west-south-west, and at times blow most violently. When the barometer begins to rise the gale ceases at south or south-south-west." Captain Benjamin Morrell, writing in 1830, states (90), "The climate is mild, temperate, and salubrious. In the month of July, the dead of winter, the weather is mild as respects cold, the thermometer never being lower than 38° Fahr. in the valleys; and the trees at the same time retain their verdure, as if it were midsummer. In December and January the thermometer was 78° Fahr." Hooker thus writes of the climate (46, p. 2), "The climate is rainy and very stormy, so that on the windward side the plants are stunted and checked, and resemble those of a higher southern latitude or of an elevation of several hundred feet above that which the same species inhabit on the sheltered parts." Some extracts from Musgrave's journal (83) give some idea of the climate in the south of Auckland Island: "Sunday, 14th February, 1864.—During the first part of the past week we had very heavy and almost constant rain; wind moderate." "This is a dreadful place for rain; but still we appear to have got to a place where it falls least." "There is one place where it scarcely ever ceases raining; this is caused by the form of the land in that particular place (which we have named Rainy Corner), which is backed by a very high mountain, which bursts the low clouds as they pass over it." "Sunday, 6th March, 1864.—The first part of the past week was very fine, but since Wednesday we have had continual drizzling rain, with light westerly winds, until midnight last night, when it came on to blow a very heavy gale, and continued ever since, with frequent showers." "Sunday, 20th March, 1864.—During the last week we have had nothing but a succession of westerly gales, which only cease for a few hours and then blow again

with great fury; and it has also rained almost constantly until yesterday at noon. Since then we have had frequent falls of hail and snow." "Sunday, 3rd July, 1864.—Blowing a strong gale at W.N.W." "It has been stormy during the whole of the past week. On Tuesday and Wednesday a considerable quantity of snow fell—all the ground was covered; but since midnight of Wednesday we have had a heavy gale from the W.N.W., with much rain, which still continues." "Sunday, 7th August, 1864.—During the whole of the last week the weather has been very bad; it has been blowing a very heavy gale from between west and north-west, with either hail, rain, or snow continually falling. From noon yesterday till 3 o'clock this morning the gale was at its height; it blew a hurricane, and was the heaviest I have ever seen while on shore. Our house is elevated about 30 ft. above the mean tide-level, and is about 50 yards from the water, and during the height of the hurricane the spray was frequently dashed against it in heavy showers. Had it not been well built, and securely, it would inevitably have been blown down." "Sunday, 21st August, 1864.—During the greater part of the past week the weather has been very fine." "Sunday, 26th March, 1865.—The sea booms and the wind howls. These are sounds which have been almost constantly ringing in my ears for the last fifteen months, for during the whole of this time I dare venture to say they have not been hushed for more than a fortnight together."

From Mr. W. Joss, who has spent at different times many months sealing on Auckland Island, I have been able to learn the following regarding the climate of spring, summer, and autumn: The rainfall is not very great, nor are the separate downpours heavy, but there are a very great number of days on which rain falls—indeed, generally speaking, it rains more or less every day. Should it rain in the morning it will most likely be fine in the afternoon, and *vice versâ*. During the summer months there is perhaps one day in each week on which no rain falls. The rain is usually accompanied by wind. There is no frost at sea-level during spring, summer, or autumn. In the sunshine it is hot, but a perfectly clear sky is a very rare event.

During my short visit to the Auckland Islands it rained slightly every day, the rain accompanied by squalls of wind. There was a slight frost at sea-level, and a small amount of snow fell. On the hills, both in the north and south of the group, were patches of snow, but Captain J. Bollons informed me that he had never seen more snow on the hills in the neighbourhood of Port Ross during any winter visit of the "Hinemoa" than was then present.

From the above details regarding the climate of the Auck-

land Islands, and from the aspect of the vegetation and the species of which it is composed, I think the following may fairly be concluded: (1.) There are a great number of rainy days. (2.) The moisture, which can easily permeate the peaty soil, will not readily evaporate owing to the almost constant cloudy skies, these also tending to keep the air full of moisture. (3.) There are very frequent winds, sometimes of great violence, accompanied by rain or sleet. (4.) The winter climate is extremely mild, much milder, indeed, than that of certain parts of the South Island of New Zealand at sea-level, as, *e.g.*, the Canterbury Plains. Of course, when in winter a south-westerly wind accompanied by sleet is blowing one feels bitterly cold, and under such circumstances an observer is apt to overestimate the coldness of the climate.

THE PLANT-FORMATIONS.

With regard to the plant-formations of the Auckland Islands, and, indeed, those of the other Southern Islands visited by me, I can only speak in quite general terms. The small extent of country which I was able to examine in a very limited time made it quite impossible to separate the vegetation as a whole into its component formations, or to properly limit or define those which were so hastily examined. Therefore most certainly only a part of the plant-formations are here dealt with, and these may in some instances include more than one formation, or, on the other hand, be too narrow in their application. There must certainly be a number of formations which I never saw at all, such as subalpine rocks, subalpine bogs, running-water formations, &c., while the open country, both of the high and low lands, most likely contains more than one formation. The formations here dealt with are: (1) Sand-dunes; (2) coastal rocks; (3) forest, divided into (*a*) rata forest, (*b*) *Olearia lyallii* forest; (4) lowland tussock; (5) *Pleurophyllum* meadow; (6) subalpine meadow; (7) subalpine scrub.

1. *Sand-dunes.*

Nothing is said regarding the sand-dunes either by Hooker or Kirk. The former author certainly speaks of (46) *Pratia arenaria* as "creeping over the open sandy shores of Enderby Island"; but this information was supplied by Lieutenant H. Oakely, so probably Hooker himself did not visit Enderby Island, the only locality in the group, so Captain J. Bollons informs me, where sand-dunes occur. These are situated on the south coast of Enderby Island, and in front of them is a somewhat extensive sandy beach (Pl. XI.),

the rendezvous of numerous sea-lions. At the time of my visit there were perhaps forty of these large animals on the beach, while others were encountered on the dunes. The heavy bodies of these creatures dragged over the ground must have some effect on the vegetation, especially as they are wont to roll about on the sand. At the present time the sand-dune formation cannot be considered quite a primitive one, since already cattle, and perhaps rabbits, have loosened the sand, so that dunes originally stable are now moving inland, and have already invaded the forest zone, destroying some of its outermost members. This fact is the more interesting because, as will be seen from what follows, the dune-plants are none of them true sand-binding plants, such as *Scirpus frondosus* of New Zealand or *Elymus arenarius* of the Northern Hemisphere, the extreme moisture of the climate, in conjunction with the short periods of sunshine, keeping the sand sufficiently moist on the surface to promote in many places the growth of a turfy covering, which is quite sufficient to keep the sand from drifting, in the absence of introduced herbivorous mammals. Even where the dunes are quite bare the climatic conditions probably would suffice to keep them stable. All the same, the absence of such a widely spread sand-binding plant as *Scirpus frondosus*, which extends even to Chatham Island, is a matter for considerable surprise.

The dunes are traversed by deep gullies, down which small streams of water flow, the drainage from some swampy ground between them and the "rata forest." Such gullies furnish plant-stations having considerable shade and moisture. On the summit of the dunes are great numbers of small stones, said to be part of the excreta of the sea-lions. Musgrave (83, p. 148) refers also to such stones, and states that he found a deposit of them in peaty soil 6½ ft. below the surface of the ground.

The dune vegetation varies from an open to a quite close formation, this latter appearing as a green sward, even when viewed from some distance (see the dark patches in Pl. XII.). The open portion of the formation appears, of course, in those places most exposed to sun and wind, and has for its plant-members a species of moss of a dense habit of growth, specimens of which I unfortunately failed to procure, stunted *Tillæa moschata*, *Ranunculus acaulis*, and *Rumex neglectus*. As all these spermaphytes are also quite common at various places on the New Zealand coast a detailed description of their life-forms is unnecessary; suffice it to say that *Rumex neglectus* and *Ranunculus acaulis* have both creeping underground stems, those of the former of considerable dimensions, by which they can easily spread in the sandy ground, while the

succulent *Tillæa moschata* roots readily from the axils of its leaves. Where such a portion of the formation has been disturbed by grazing animals, and its vegetation more or less destroyed, *Rumex neglectus* is in many places taking entire possession, and a pure formation of this plant, foreign to the primitive vegetation, may in such places occupy the ground for some time to come, thanks to its power of rapid increase by means of stout underground stems.

On the shady side of the gullies, and extending thence on to the summit of the dunes, is a close turf of the moss before mentioned associated with the endemic *Epilobium confertifolium*, *Pratia arenaria*—a species very common in Chatham Island, but probably not found in New Zealand proper—*Lagenophora forsteri*, and *Ranunculus acaulis*. The leaves of the *Pratia* were more or less withered, but the other members of this formation were quite green, especially the moss species, which is the dominant plant, and gives the distinct green colour to the formation, as stated above. Of the above species the only one to be spoken of here is *Epilobium confertifolium*. This is a creeping-plant which frequently forms rather dense patches on the surface of the ground. It is by no means confined to the dunes, but occurs in the forest, the meadows, and probably in other stations. A New Zealand mountain *Epilobium* is frequently referred to this species, but Mr. D. Petrie has more than once informed me that he considers the two as quite distinct, and with this I most certainly agree. The old shoots are prostrate and dorsi-ventral, the leaves being inserted on their flanks; but the young shoots are raised slightly from the ground, and here the leaves are in a spiral. The creeping stem is green, and ± 1·75 mm. in diameter. The leaves are slightly fleshy, bright-green in colour, and provided with a short but rather stout petiole. The leaf-blade is ± 12 mm. × ± 6 mm., and has a rounded apex and a slightly toothed margin. The young shoots in spring grow closely together. Roots ± 4·6 cm. in length are given off here and there from the prostrate stem. Seeds germinate very readily in cultivation. The flowers are bright-pink in colour, and the peduncles are extremely short. Plants brought from the Southern Islands came into bloom on the Canterbury College rockery early in November. Although growing on a sand-dune, the short roots are sufficiently long both to anchor the plant and reach the water. Whether the distichous arrangement of the leaves is hereditary or whether it is merely a non-hereditary light relation only experiment can show. The colour of the flowers is an uncommon one amongst New Zealand plants, and is dealt with further on.

2. *Coastal Rocks.*

Here is included both the flat rocky shore and the basaltic cliffs, which latter are frequently perpendicular, but contain many ledges, crevices, and hollows, on or in which peat, so easily and quickly formed from decaying vegetation in the climate of all these islands, can lodge. This plant-formation of the rocks is a most important one in the Auckland Group, since by far the greater part of the coast-line consists of cliffs, which must offer the most varied situations for plant-life. On this account a detailed account of the distribution of their plant-inhabitants with regard to the various ecological factors would be of considerable phytogeographical interest. My observations, however, were confined to a very rapid examination of a few coastal rocks at Ewing Island and Rose Island. I also walked for some short distance along the stony shore of the north coast of Adams Island, and spent a few minutes on the summit of those rocks at its western corner where the narrow strait connects Carnley Harbour with the Southern Ocean. Thus, since it was impossible, under the circumstances, to obtain any true conception of a typical rock-formation, and also as the composition and physiognomy of this formation will probably vary to some extent in various parts of the group, it seems best to deal with each locality separately.

On the flat rocky shore of Ewing Island, raised but little above high-water mark, and very frequently drenched by the sea-spray, the endemic *Cotula lanata*, its thick stems creeping over the rock and rooting in places from the nodes, is very abundant. Growing in a similar position, and rooting into the chinks of the rock, are the large, green, hard cushions of *Colobanthus muscoides*. Close beside this latter, and frequently growing on its surface, is the reddish-coloured *Tillæa moschata*. Scattered about here and there are the soft green tufts of *Scirpus aucklandicus*, while flattened close to the rock are the green rosettes of a species of *Plantago*, probably endemic, and which was referred by Hooker first to *P. carnosa* and finally to *P. brownii*. Rising from the flat rocks of the shore are perpendicular basaltic cliffs, on the summit of which, growing in the ever-present peat of these islands, are large green bushes of *Veronica elliptica*, or in another part of Ewing Island the magnificent *Olearia lyallii* crowns the cliffs; but neither of these plants belong to the formation now under discussion, although perhaps the *Veronica* may grow on the coastal cliffs in some part or other of the group, since such are a very common station for this plant in the South Island of New Zealand. Where the rock is wettest—and these rocks often fairly drip with water—the curious indigenous grass *Poa ramosissima* is very abundant, the pale-green of its leaves

giving a distinct colour to the formation. On the peat-covered ledges of rock the halophytic grass *Festuca scoparia*, also common on coastal cliffs in the South Island of New Zealand, grows abundantly and luxuriantly. Here, too, the xerophytic ferns *Lomaria dura* and *Asplenium obtusatum* form dense and large masses, their rhizomes, roots, and decaying fronds being very efficient soil-producers. Finally, in many places *Cotula lanata* trails its stems down the rock-faces.

The cliffs of Rose Island, where we landed from the "Hinemoa's" oil-launch, are almost perpendicular, and are still wetter than those mentioned above. Here *Poa ramosissima* clothes them so densely as to make a close formation, a most uncommon event for the vegetation of rocks. The masses of this grass measured quite 20 cm. through to the wet peat in which it was rooted. Here, too, *Festuca scoparia* helps to make the close mass of vegetation, its leaves hanging downwards for more than 1·5m., their tips almost dipping into the sea at high-water. On the wet ledges not covered with grasses are *Callitriche antarctica* and tufts of *Scirpus aucklandicus*. My notes do not mention the customary maritime ferns, but it may be taken for granted that they are present, and also probably *Cotula lanata;* indeed, the cliffs here have the same vegetation as those treated of above, but owing to their greater moisture their vegetation is more luxuriant.

The stony beach of Adams Island, facing the Western Arm of Carnley Harbour, abuts on the *Pleurophyllum* meadow, no forest or scrub zone in many places separating the two formations. In consequence of this, and perhaps also because it is not much exposed to sea-spray, some of the characteristic meadow-plants, notably the very fine umbellifer *Ligusticum latifolium*, grows amongst the stones of the beach. Here also *Cotula lanata* and the closely related *Cotula plumosa* are abundant.

On the summit of the rocks at the western corner of Adams Island, at perhaps 50m. or so above sea-level, is *Plantago* sp. and the very common New Zealand halophyte *Samolus repens*. At times during heavy weather the plants of these rocks must be drenched with sea-spray. Mr. E. Lukins describes how he found "large pieces of kelp, seaweed, broken shells, and starfish" on these cliffs, "all thrown up by the force of the huge seas"(75). This must be the station where Kirk collected *S. repens*, and if it occurs nowhere else in the Auckland Group or in the Southern Islands it is a most interesting and instructive example of local distribution, similar in character to examples of other species of spermaphytes in Chatham Island, which I have pointed out may be considered relics of a former vegetation much richer in species (23, p. 316).

Besides the various species of plants enumerated above as belonging to the coastal-rock formation, the following are mentioned in the "Flora Antarctica": *Myosotis capitata*, growing "on gravelly banks near the margins of woods close to high-water mark"; *Gentiana cerina*, "near the sea on rocky islets in Rendezvous Harbour"; *Urtica australis*, "on the pebbly beach above high-water mark"; and *Urtica aucklandica*, "on the sea-beach." Of these plants, *Urtica australis* is a very common plant near the sea on the shores of the large lagoon in Chatham Island (23, p. 273), and also it occurs abundantly at certain spots on the gravelly shore of Dog Island and Centre Island, in Foveaux Strait; while *Gentiana cerina* is closely related ecologically to *G. saxosa*, a most abundant plant of the coastal turf in the neighbourhood of Foveaux Strait.

Regarding the life-forms of the plants of the formation under consideration, only those which are endemic need any detailed description here, while of these those belonging more strictly to the meadow, or to a zone between meadow and shore, will be treated of further on. To the first category belong *Cotula lanata (Compositæ)*, *Colobanthus muscoides (Caryophyllaceæ)*, *Plantago* sp. *(Plantaginaceæ)*, *Poa ramosissima (Graminaceæ)*, and *Urtica aucklandica (Urticaceæ)*.

Cotula lanata has pale-green or sometimes brown prostrate stems, which creep along the ground or hang down the face of vertical cliffs. They are ± 12 mm. in diameter, but are usually rather wider in the horizontal than in the vertical direction, thick, fleshy, and with a smooth surface. The extremities of the stems are ascending, bending upwards and bringing into the light the terminal leaf-rosettes, which consist of a few spreading pale-green pinnatifid leaves. The stems are marked at intervals of ± 6 cm. with old leaf-scars, and from some of the nodes roots pass downwards into the rock-crevices, thus firmly anchoring the plant to the substratum. Shorter or longer lateral branches are frequently given off from the main stem. The leaves are fleshy and vary somewhat in colour, those innermost and not fully developed being of a darker green than the larger and more external ones. In shape they are obovate, the blades deeply pinnatifid, ± 15 mm. long × ± 12 mm. broad, and the segments are toothed on the upper margin. Such teeth, ± 2 mm. long, are bent at an angle, frequently almost at a right angle, to the plane of the leaf, thus making one-third of the assimilating surface vertical or nearly so, while the remaining two-thirds is horizontal. The fleshy pale-coloured petiole is nearly twice as long as the lamina, and possesses a broad sheathing base ± 5 mm. long, furnished with a membranous margin. The petiole and midrib are covered, especially in young leaves,

with cottony hairs loosely interwoven. Thus, the sheathing petioles and the persistent remains of the leaf-sheath and leaves of the preceding year form an efficient protection for the delicate bud. Early in spring new shoots are put forth from near the apex of the branches at the same time that the flower makes its appearance, such shoots in three weeks in cultivation attaining a length of ± 3 cm. The leaves close to the end of the shoot are arranged spirally, but the remainder are brought into two ranks through twisting of the leaf-sheaf, the leaf-surface thus becoming horizontal. This dorsi-ventral habit seems hereditary, a stem which had been planted so as to be vertical at a height of 5·4 cm. from the ground put forth in spring three dorsi-ventral shoots, which stretched out in the air parallel to the ground and at right angles to the vertical stem. The internodes of young shoots are densely covered with loose white cottony tomentum. The flower-heads are 7 mm. in diameter, the florets yellow in colour and densely packed together; the peduncles are ± 1·3 cm. long, and tomentose.

Colobanthus muscoides is an extremely dense cushion plant, more or less circular in outline, with a convex upper surface. The shoots are packed as closely together as those of the "vegetable sheep" (*Raoulia mammillaris*), so that the plant as a whole can be quite easily removed from the ground, and when dry makes an interesting museum object. These dense cushions are bright-green in colour, and vary considerably in size, a large one measuring 54 cm. in diameter. The leaves are linear in shape, quite glabrous, ± 6 mm. in length × 1 mm. in breadth, and fleshy. They form little rosettes of about six leaves each at the extremity of each shoot. Below—that is, within the cushion—the old leaves are all in a greater or less advanced stage of decay, and form a dense, yellow, sticky, peaty mass ± 10 cm. in depth, through which the shoot-axes penetrate, giving off at the under-surface of the cushion a large number of fine roots. The peaty mass absorbs water like a sponge, and in the wet climate must nearly always be saturated with moisture.

The endemic species of *Plantago* forms rather hard green round rosettes, often pressed closely together and flattened close to the surface of the rock. These rosettes measure ± 4 cm. in diameter. The leaves are fleshy, rather stiff, and bright-green in colour. Those of the periphery are the longest, those more internal being shorter, but broader in proportion to their length. The epidermis is strongly cuticularised on the upper surface. There is a dense palisade parenchyma, and a rather close, round-celled spongy parenchyma. Numerous resin-passages are present. The root-stock is short and thick, and gives off several long deeply

descending roots. Sometimes the rosettes are so close together as to be mixed up with one another, and in such cases the rosette-form is not evident.

Poa ramosissima is, as Hooker pointed out, "a grass of remarkable habit." The long wiry decumbent stems, 1 mm. or more in diameter, are often quite naked below, but above are covered with the membranous leaf-sheaths of the preceding year ± 4·5 cm. long. Above a great number of leafy branches are given off. The leaves are very numerous; the leaf-blade ± 5 mm. long, ± 2 mm. broad, pale-green, flat, soft, and flaccid.

Urtica aucklandica was not observed by me. According to Hooker it is a rare plant. It is described in the Handbook as "herbaceous, robust, softly downy all over, except the upper surface of the leaves, where there are a few stinging hairs. The leaves are broadly ovate-cordate, coarsely serrate or toothed, rather coriaceous or rigid. Petioles stout, ½ in. to 1 in. long."

3. *The Forest-formations.*

As in the case of the formations already described, I can make no definite statements as to the limits of the forest. It seems best here, then, to give some details regarding each of the pieces of forest visited by me. There are two very distinct types of forest. The first, and by far the most common, is that in which *Metrosideros lucida* is the dominant tree. The second, which is extremely local, consists of *Olearia lyallii*. For the former formation I propose the name "rata forest," and for the latter "*Olearia lyallii* forest."

(a.) *The Rata Forest.*

This formation forms a belt of evergreen trees and shrubs extending round a considerable portion of the coast of the various islands, its distribution depending probably upon the nature of the soil, exposure to wind, and altitude of the land. Thus, the rata forest is most luxuriant at the heads of sheltered inlets, while in places exposed to the full violence of the frequent gales it is altogether wanting, and at a certain altitude, averaging possibly 120m., it gives place to formations of scrub or meadow. Where high cliffs form the coast-line the forest is absent, and where there is excessive moisture in the ground a tussock formation may occur side by side with the forest, as in certain parts of Enderby and Ewing Islands. Regarding the distribution of the forest, Chapman states (15, p. 501), "The north coast is almost without wood; this may be due to lack of shelter. The west coast is too steep for trees; so is the external part of the south coast."* I

* This evidently refers to Adams Island.

had an opportunity of examining the forest in the following places: Enderby Island, where I almost passed through the belt into the tussock beyond; Ewing Island; near the depot at Port Ross, in the north of Auckland Island; at the head of Musgrave Inlet; at Camp Cove, Carnley Harbour, where I ascended right through the forest-belt on to the subalpine meadow.

On Enderby Island there is a considerable quantity of rata forest and scrub, which forms a somewhat narrow belt on the east and south sides, the whole of the west side of the island, according to Captain J. Bollons, being a tussock formation. This forest-zone consists of *Metrosideros lucida* and *Dracophyllum longifolium*, with an undergrowth of *Suttonia divaricata*, *Coprosma fœtidissima*, and the semi-arborescent fern *Aspidium vestitum*. Proceeding through the forest to the north, the *Metrosideros* becomes less in quantity and more stunted, while *Cassinia vauvilliersii* makes its appearance, this shrub finally becoming dominant. It seems from this that we have here to do with two formations—viz., the true rata forest and a scrub in which *Cassinia vauvilliersii* is the leading plant—but I have not sufficient data to make any statement on this head. My notes say nothing about the height of the *Metrosideros* trees; probably they are some 5m. tall. The view within the forest is amazing in the extreme, and to give a lifelike and vivid word-picture of the appearance of the trees is quite beyond my powers of description. The trunks of the ratas are frequently prostrate from their bases for more than half their length. From such prostrate trunks are given off many naked branches much twisted and gnarled. The ultimate branchlets are erect, and form with the foliage a dense flattened head to the tree, whose spread is altogether out of proportion to its height. Such spreading branches may measure ± 60 cm. in diameter. In this forest *Dracophyllum longifolium* is common, and is frequently furnished below with many "reversion-shoots," having much broader leaves than those of the adult and similar to those of juvenile plants. Viewed from a slight eminence, the roof of the forest presents a dense green appearance, and one thus viewing it from above would think the whole formed a thick, low, shrubby growth such as the heaths of northern moorlands. Through the rata-foliage the *Dracophyllum* puts forth its erect, straight, needle-like leaves for a short distance. The undergrowth consists of shrubs of *Coprosma fœtidissima* and the very densely growing *Suttonia divaricata* (76), while the fern *Aspidium vestitum* spreads out abundantly its arching dark-green fronds of 1m. or more in length. The floor of the forest here, as in all parts of the Auckland Islands, consists of wettish peat. In many places it is bare, perhaps owing to the

sea-lions lying down upon it and wallowing in the mud, for the comparatively wide tracks of these animals are very numerous. Indeed, but for such tracks, in many places churned up into thick mud, progress through this dense forest would be far more difficult. Where the forest-floor is not bare numerous rounded patches of mosses and liverworts are present, also seedlings of the various trees and shrubs are very common, while *Nertera depressa*, its stems creeping on the ground, and the species of *Uncinia* formerly known as *U. hookeri*, but now referred by Kükenthal to *U. riparia* as var. *pseudorupestris*, are abundant. Here and there are a few plants of *Urtica australis* and stunted *Stilbocarpa polaris*. *Epilobium linnæoides* and *Stellaria decipiens* are also frequent. As one penetrates further into this forest towards the north the shrubs increase in number, *Cassinia vauvilliersii* appears, and progress through the dense shrubby growths becomes extremely difficult.

The rata forest on Ewing Island is very similar to that just described; but, if possible, the curious twisted branches of the rata in that portion of the forest visited by me were even more striking. Some of these branches extend for a long distance at right angles to the main stem, others are given off at all kinds of angles and twisted on their axes, the whole mass of branches making a most bewildering network. Here, too, the forest-floor is frequently quite bare, no doubt owing to the great numbers of sea-lions, which formidable-looking creatures were constantly encountered.

In Erebus Cove, Port Ross, stands the depot for castaways. It was in this neighbourhood that for three years Enderby had his headquarters, and during that period cut down several acres of the forest. In this same locality, so Captain J. Bollons informs me, the early whalers also cut down a considerable number of trees, filling their vessels with wood before proceeding to Campbell Island, where true forests are wanting. Where this extensive clearing was made there is now a dense growth of evergreen shrubs, forming a most beautiful shrubbery of various hues of green. An account of the constituents of this new formation is given further on, when dealing with the effect of introduced animals, &c., on the vegetation.

The most luxuriant forest that I had an opportunity to examine is that at the head of Norman's Inlet, but, unfortunately, only a few minutes were available, it being late in the afternoon when we landed. The position of this forest possibly affords the maximum amount of shelter to be found on Auckland Island, and in consequence the trees are taller than in the more exposed forests, and the interior hygrophytic vegetation richer both in quantity and species. A

stream of considerable size from the adjacent rugged mountain also adds its quota to the moisture of the atmosphere. The remarkable broad-leaved form of *Polypodium australe—P. rigidum*, Homb. and Jacq.—is here abundant. The plants collected by me seem to match those figured in "Voyage au Pole Sud" (45, pl. ii., Monocot. Vasc.). The fronds measure ± 14·5 cm. × ± 2 cm., are given off from a stout rhizome ± 4 mm. in diameter, and form tufts on the tree-trunks. This plant is very different in appearance from the typical species, also abundant in the same forest, nor did I notice any "intermediate forms." In this forest Mr. W. Joss made a most interesting discovery—viz., one plant of the common New Zealand tree-fern *Hemitelia smithii*, tree-ferns, if we except *Aspidium vestitum*, not having been previously observed in any of the Southern Islands. This important discovery extends the range of tree-ferns very much further to the south than was previously known.* Unfortunately, I had no time to pay the plant a visit, so only saw the specimens which Mr. Joss had just collected. The general character of this part of the rata forest is very similar to that next to be dealt with, so to avoid needless repetition no more need be said here.

Passing into Carnley Harbour at first a dense belt of forest clothes either shore, extending up the steep mountain-slopes for perhaps 150m.; but after the Western Arm is reached the upper meadow comes lower, until finally it descends to sea-level, alternate bands of forest and meadow clothing the slopes. Such grassy spurs offer a most excellent opportunity for reaching the higher ground of Adams Island, doing away with the laborious climb through the forest necessary in most parts of Auckland Island before the subalpine region can be reached. I had no opportunity to examine the Adams Island forest, but several hours in the neighbourhood of Camp Cove afforded me facilities to examine the forest in the south of Auckland Island.

At Camp Cove the trees come right down to the edge of the water, into which the leaves of *Dracophyllum longifolium* almost dip. Here *Metrosideros lucida*, as usual the dominant plant, grows with spreading gnarled branches, but hardly to the same degree as in the more wind-swept forest of Ewing Island. The accompanying photograph (Pl. XIII.) gives, however, only a poor idea of the interior of a rata forest, since in order to get near and distant objects into focus a rather open part of the forest had to be selected. Mixed with the rata is *Panax simplex* and *Dracophyllum*

* Mr. W. Botting Hemsley, F.R.S., has kindly informed me that the previously recorded limit of tree-ferns was that of *Alsophila pruinata*, at about 47° S., in Port Otway, Patagonia.

longifolium. The forest-roof, as before described, is of extreme density, and it is situated some 4·5m. above the surface of the ground. Such a dense covering, combined with the great amount of moisture in the atmosphere, affords very strong hygrophytic conditions within the forest, with the result that plants of the most marked hygrophytic structure abound, and grow with great luxuriance. The forest floor is extremely uneven. Large mounds, formed in part of decayed vegetation, consisting principally of mosses and liverworts, are very common. Such mounds, the forest-floor in general, and the many fallen and dead tree-trunks are densely covered with liverworts, mosses, and filmy ferns, the two former frequently forming great cushions. These same plants are also epiphytic on the tree-trunks and stout spreading branches of the rata, forming finally, in many cases, deep masses of soil, in which seedling trees and shrubs grow with vigour. *Hymenophyllum multifidum* and several other filmy ferns form sheets on the bark of the trees, while *Polypodium billardieri*, one of the most characteristic plants of this forest, climbs over their trunks, and also ramifies over large areas of the forest-floor. Frequently this latter is quite occupied by an extremely dense and deep undergrowth of *Aspidium vestitum*, or, nearer the shore, there is much *Asplenium obtusatum* and *Lomaria dura*. In other places the ferns may be replaced almost altogether by a still denser undergrowth of *Suttonia divaricata*, so close that the shrubs touch one another. In such places as this, but for the seals' tracks and what I took to be pigs' tracks higher up, but which may also be made by seals, progress through the forest would be much more difficult.

If we consider the climatic and edaphic conditions to which the rata formation is subjected we find them extremely diverse. There is on the one hand the almost constant wind, which very frequently assumes the character of a furious gale —a strongly marked xerophytic factor. There is also a very wet, badly drained, peaty soil—a soil, indeed, probably to some extent physiologically dry—a second xerophytic factor. But on the other hand is a climatic condition diametrically opposite to the above, one strongly hygrophytic indeed — namely, an extremely moist and equable climate, which favours forest-growth exceedingly, and would be an ideal rain-forest climate (92, p. 505) were the mean summer temperature not so low. The physiognomy and interior contents of the forest is the resultant of these opposing factors. Thus, there is every indication of the mechanical action of the wind on the trees causing the flat dense roof of foliage and gnarled trunks and branches ; but the moist climate at the same time encourages the spread of the forest as a whole, and the luxuriant lateral growth of the branches, which is out of all

proportion to the height of the trees. Moreover, the dense roof of the forest assists in keeping its interior calm, and here the hygrophytic factors can exercise full sway, so that the vegetation within the forest is of the most extreme hygrophytic character, and its constituents the filmy ferns, liverworts, &c., such as can endure only for a very limited period dry air or exposure to direct sunlight. The light factor, indeed, is a very important one so far as many of these forest plants are concerned. Feeble light is of as much importance in the cultivation of certain liverworts and filmy ferns as is moist air, and the letting-in of more light into a New Zealand rain-forest when timber is being removed has perhaps the most to do with the death of a large percentage of the hygrophytes.

This rata forest of the Auckland Islands is by no means altogether an endemic plant-formation. Very similar forests are found in certain parts of the South Island of New Zealand and in Stewart Island, but they contain more arborescent components — notably, *Weinmannia racemosa* is a frequent member; nor is the general physiognomy the same. This interesting fact—the occurrence of a very similar formation in two regions so distant—is discussed when dealing with the history of the vegetation.

Since all the plants of this formation, if we except the fern *Polypodium rigidum*, occur in New Zealand proper but little need be said here as to the life-forms of most of them. The general aspect of *Metrosideros lucida* has been sufficiently described above; its lanceolate, thick, coriaceous, shining green leaves furnished with numerous oil-glands, their blades $\pm$ 3·6 cm. $\times$ $\pm$ 1·6 cm., growing closely together, are quite able to withstand the most violent winds so long as the atmosphere is charged with moisture. On the dry Canterbury Plain the hot north-west winds do not allow this tree to be brought into cultivation, whereas in Dunedin, where this wind is unknown or extremely modified, the rata flourishes in gardens, though not a member of the forest of that locality. The narrow semi-vertical needle-like leaf-blades of *Dracophyllum longifolium* have their transpiring surface still more reduced by the concavity of the upper (inner) surface, and are, moreover, confined to the extremities of the ultimate branchlets. Like *Dracophyllum arboreum* of Chatham Island (22, p. 294), *Drac. longifolium* has juvenile leaves broader than those of the adult, and it also frequently puts forth "reversion-shoots," as mentioned above. Such shoots have leaves much broader and longer than those of the adult, and they closely resemble the juvenile leaves. In the juvenile leaves the position with regard to light is different from that of the adult leaf, the surface of the former being almost horizontal, while the latter is semi-vertical. There are also differences

in size and colour, juvenile leaves being nearly twice as broad and 1·5 times as long as adult leaves; while, as to colour, the juvenile leaves are reddish-brown and the adult are green.

Panax simplex is a plant which exhibits a still more remarkable heterophylly, which, as I stated some years ago (21, p. 355), is not yet understood. Since that time I have been collecting material, and hope to publish my results shortly. As, however, I collected some special evidence on this matter on Auckland Island it may be briefly discussed here. According to Kirk *Panax simplex* has two quite distinct primary juvenile forms through one or other of which it must pass before it assumes its second later juvenile form and its final adult form. One of the primary juvenile forms has simple leaves and the other has compound leaves, these being, according to Kirk (66, p. 217), "five-foliate on slender peduncles; leaflets petiolulate, linear lobed or pinnatipartite." In his "Forest Flora" Kirk gives figures of the various forms (65, pl. cvi., cvii.). Now, the point which chiefly concerns us here is that Hooker stated that only the entire-leaved seedling form was found on Auckland Island, while Kirk affirms, "It [the entire-leaved form] is the prevalent form on Stewart Island, but the lobulate form occurs there also" (65, p. 211). Taking for granted that the fact of the occurrence of these forms as here stated was correct, I wrote some time ago (22, 355), "Different environment, as will be shown later on, has a most marked effect on the same forms in many plants; hence this case, granted that the facts are as stated, may be merely a case of different development under different conditions." In the accompanying plate may be seen figures of various forms, which certainly throw a new light on our knowledge of this important biological matter. Fig. 1, Pl. XI., shows that the form with deeply cut leaves also occurs in Auckland Island, the seedling in question being collected by me in the forest at Norman's Inlet. Fig. 3 shows a 5-foliate and rather deeply cut leaf, which occurs, moreover, on the same shoot with a ternate leaf (fig. 4). Turning to plants collected by me at Port Pegasus, Stewart Island, in the "rata-pine forest," fig. 5 shows the simple-leaved form and fig. 6 the cut-leaved compound-leaf form on the same plant. This latter, at any rate, shows that the entire-leaved seedling and the compound deeply cut-leaved seedling are not distinct from one another. The subject has now reached the stage when experimental treatment is demanded. Probably moist air has something to do with the stimulating an hereditary tendency to produce compound trifoliate deeply cut leaves; but, as I said above, I hope to have some definite statements to make shortly on this matter. The adult form of *P. simplex* has simplex, oblong-lanceolate, coriaceous leaves, the laminæ

measuring 6·5 cm. × 2·25 cm., or frequently they are of somewhat lesser dimensions.

Coprosma fœtidissima varies very considerably in the form and size of its leaves; so much so, in fact, that Hooker made two species out of the various forms of the Auckland Islands, the one *Cop. fœtidissima* and the other *Cop. affinis*. This latter is distinguished from the type by its larger and longer leaves, the apex of which is acuminate. Later on Hooker merged both forms into one species. Amongst my specimens are none which match the figure in the "Flora Antarctica," but, generally speaking, the leaves are larger than those of specimens collected in such a moist habitat as the forest near Preservation Inlet. Seedlings of forms which in the adult have leaves with their laminæ 5·9 cm. × 2·1 cm. have large leaves at quite an early age, a plant 8 cm. tall having the lowest leaves 2·5 cm. × 1·6 cm., and the uppermost 3·5 cm. × 2 cm.; indeed, such seedlings have larger leaves than the average adult leaves of plants at Preservation Inlet. Leaves from rapidly growing suckers are of still greater dimensions, measuring 7 cm. × 3 cm.

Suttonia divaricata belongs to that class of shrubs which I have elsewhere designated as xerophytic,* and which bear especially the impress of exposure to strong dry winds and a dry soil. Such shrubs are very frequent in New Zealand, and belong to very different genera, or even natural orders, yet so much resemble one another that some botanical knowledge is required to discriminate between them. Some lianes, too, assume a similar habit of growth in the open, and are frequently associated with the plants in question in such stations as stony *débris* on dry hillsides or on river-terraces. These plants are distinguished by the possession of thin, wiry, interlacing, frequently divaricating branches, the whole forming a dense mass so strong as to almost support the weight of a man, and which can be reclined on as on a wire-wove mattress. The leaves are of small size, more or less coriaceous, and in some cases few in number. Amongst the commonest plants of this class are several species of *Coprosma (Rubiaceæ)*, *Aristotelia fruticosa (Tiliaceæ)*, *Pittosporum rigidum (Pittosporaceæ)*, *Panax anomalum (Araliaceæ)*, species of *Hymenanthera (Violaceæ)*, *Corokia cotoneaster (Cornaceæ)*, the plant under discussion — *Suttonia divaricata (Myrsinaceæ)*, and amongst lianes species of *Rubus (Rosaceæ)*, *Mühlenbeckia complexa (Polygonaceæ)*, and *Clematis afoliata (Ranunculaceæ)*. *Suttonia divaricata* possesses in a marked degree the habit mentioned above. The ultimate branchlets at the outside of the plant are

* Trans. N.Z. Inst., vol. xxxiii., p. 279. 1901.

straight and stiff, ± 3 mm. in diameter, and given off from the more internal and thicker branches at right angles, and sometimes at a lesser angle. The main trunk, according to Hooker, is 10 in. or 12 in. in diameter (46). The leaves are numerous, somewhat coriaceous, and their laminæ measure about 11 mm. × 10 mm. The figures in the "Flora Antarctica" and "Das Pflanzenreich" (77, fig. 56, p. 334) furnish some idea of the appearance of a small branch of this shrub, but give little notion of the aspect of the plant as a whole. Contrary to the majority of the above-mentioned xerophytic shrubs, *S. divaricata* usually occurs in the rainy regions of the New Zealand biological area. Such a structure as that described above seems quite unsuited for moist forest regions, and its presence and that of other xerophytic plants can, it seems to me, be only explained on those historical grounds which Dr. L. Diels was the first to suggest. These were that during the great rise of the land, which according to Hutton led to the remarkable extension of the glaciers of New Zealand (53), a steppe or semi-desert climate would exist on the new tableland and plain in the east of New Zealand, and that the plants of that region would require to be modified in accordance with the changed conditions of their existence—from a rain-forest climate to a semi-desert climate—or perish. In accordance with this view, as the land receded to its former small area some of the plants would be left in outlying stations no longer connected with New Zealand proper, such as Chatham Islands and the Southern Islands; others would find a congenial habitat in the extreme xerophytic stations of limited area still remaining in the east and centre of the North and South Islands; finally, others would get mixed up with the western vegetation at a time of a further sinking of the land, when some of the passes over the Southern Alps would be about 305m. lower than at the present time. But this matter is too important to discuss in the limited space here available; I can only refer the reader to Diels's original paper (27) and to some further remarks on the subject published by me elsewhere (23). One matter of interest in this connection lies in the fact that *Suttonia divaricata* shows the rigid divaricating habit of growth in seedlings at quite an early age. Thus, a seedling 6·4 cm. tall has a rigid stem 2 mm. in diameter; near the first leaves one short, straight branch is put forth from the main stem at an angle and in a manner similar to that of the adult; also, the leaves are equal in size and similar to adult-leaves, except that some of them are more or less toothed or slightly lobed on the margin. So far as I have observed up to the present, it is exceptional for a New Zealand xerophytic shrub

to have leaves similar to the adult; on the contrary, these plants offer instructive examples of what Goebel calls heteroblastic development, thus giving a clue from the study of the development of seedlings to the phylogeny of the species.

As for the remainder of the forest-plants which have not yet been described, little can be said here. They are mainly such as occur in the rain-forests of New Zealand, and are mostly typical hygrophytes. Many of these, however, lead an epiphytic life, and are provided—amongst the liverworts more especially—with many remarkable adaptations towards that mode of existence.

(b.) *The* Olearia lyallii *Forest.*

This is a forest-formation of remarkably local distribution. It is not found at all in New Zealand proper, but occurs only on the Snares, on Ewing Island, and perhaps to a very limited extent in one or two places on Auckland Island itself And yet where it does occur it grows with great luxuriance; seedlings of all sizes are abundant. Nor does there seem any reason why it should not be the dominant forest of the Southern Islands. We have here possibly one of those cases where a very slight difference in adaptation to environment, not to be estimated in the present state of knowledge, has led to one formation becoming dominant and another remaining stationary in a limited area; or, what is perhaps likely here, a former primeval forest adapted to slightly different conditions has been ousted by a newer formation as the conditions changed.

"Viewed from the sea," to quote from my note-book, "Ewing Island has a decidedly attractive appearance." This is owing to the fine natural shrubbery of *Olearia lyalli* which fringes the shore, its huge leaves exposing their silvery undersurface as blown by the frequent wind, and contrasting finely with the green of the upper surface. Alternating with the *Olearia* are pale-green clumps of *Veronica elliptica*, while in front of it are in places dense tall tussocks of some species of grass, more than 1·5m. in height, with "trunks" similar to those of the "niggerhead." In front of the tussock again is a rather dense growth of the bright-green grass *Poa foliosa*. Near the depot the beach is stony, consisting in part of boulders strewn with seaweeds and in part of solid rock worn down to sea-level, backed up by low rocky faces dripping with water, and their summits crowned with *Veronica* or *Olearia*.

The individual trees of the formation are some 6·1m. to 9·1m. tall, some being erect, while others have the lower part of the trunk prostrate. Such trunks are $\pm$ 50 cm. in diameter. From very near the base the main trunk branches into three or four secondary trunks covered with a rough

bark. The ultimate branches divide into several short branches radiating upwards and outwards after the manner of *Olearia chathamica* of Chatham Island (23, p. 298), *O. operina* of the west coast sounds, or *Rhododendron ponticum*, so common in gardens, finally giving off from near their extremities numerous large leaves, which form a dense mass. These leaves are thick and coriaceous, their laminæ $\pm$ 20·5 cm. $\times$ $\pm$ 13·5 cm., and provided with a short stout petiole expanded and sheathing at the base. The upper surface is dark-green, varnished and quite glabrous except at the margins and on the broad midrib. The under-surface is densely clothed with flannelly tomentum quite white in colour. This tomentum is rather more than half the thickness of the leaf-substance proper. The midrib on the under-surface of the leaf is excessively stout, measuring at the base 9 mm. $\times$ 4 mm. The young leaf, just when it is unfolded from the bud, is white and soft like a piece of flannel, being extremely tomentose on both surfaces. The ultimate shoot-axes are 1·5 cm. in diameter, and densely covered with white tomentum similar to that of the leaf. Shade-leaves are rather larger than sun-leaves, and have the veins less prominent. A cross-section of the leaf shows a large-celled epidermis on the upper surface, having the outer wall but little thicker than the inner walls. There is a dense palisade parenchyma with water tissue extending in places into it from the epidermis. Round the vascular bundle is a stereome sheath which extends to the upper epidermis, while on its under-surface is a large-celled water tissue. On the under-surface are a number of glandular hairs.

In the forest of Ewing Island trees with prostrate trunks are very much more common than those whose trunks are erect. As a rule, indeed, more than half the trunk is prostrate upon the ground. Kirk thus describes *Olearia lyallii* as it grows on the Snares (56, p. 215), "When growing in level situations it is erect, with open spreading branches, but when growing on slopes exposed to the wind it is often inclined or with a prostrate trunk, the roots partly torn out of the soil; and the branches, rooting at the tips, give rise to new trunks, which in their turn are brought to the ground and repeat the process." As for the plants on Ewing Island, Kirk writes (56, p. 219), "Most of them are erect and well grown, but a few exhibit the inclined position so frequent on the Snares." Chapman thus describes the behaviour of *O. lyallii* on the Snares: "When this" [*O. lyallii*] "grows a certain height it falls down with the weight of the leaves and the pressure of the wind and takes root where it touches ground; then it grows upwards again, and after a while it falls again, tearing its oldest roots up and rooting itself a third time: thus the

trunk is almost gifted with the power of locomotion" (16, p. 494). I have given the above quotations partly because they differ somewhat from my account and partly because this prostrate habit seems to me a matter requiring further investigation as to its causes. That it may at the present time be frequently caused by the wind no one can deny, but there is no reason on that account why the prostrate habit should not be, in part at any rate, hereditary. The behaviour of seedlings may furnish a clue. In the interior of the forest beneath the dense leafy canopy the air is comparatively still, when without a gale is blowing. Of the quite young seedlings growing in the ground which I examined, and of which only a few leaves were developed, most had their stems prostrate on the ground for more than half their length. In one instance, in an older plant, 30 cm. was erect and 15 cm. was prostrate. On the other hand, a number of young seedlings growing closely together on the trunk of a tussock were orthotropous, but in this case density of growth or their relation to gravity may have caused the difference. At any rate, it is an interesting matter requiring further investigation, for it bears directly on the inheritance of acquired characters.

The floor of the *Olearia lyallii* forest consists of coarse peat covered with numerous fallen leaves in various stages of decay. For the most part it is quite bare, owing probably to the incursions of the numerous sea-lions. There is no undergrowth of shrubs, consequently the forest is much more open than is the rata forest. Growing on the forest-floor are many rather distant patches of young *Olearia* plants, while in other places are *Asplenium obtusatum* and *Lomaria dura*. The young plants of *O. lyallii* early on develop quite large leaves; *e.g.*, a plant 30 cm. tall had leaves measuring 13 cm. × 8 cm.

Ecologically and floristically the formation under consideration is related to the *O. chathamica* formation of Chatham Island, the *O. colensoi* formation of Stewart Island, and the *O. operina* + *Senecio rotundifolius* formation of the west coast sounds, though all three must be designated scrub, and not forest. Like the above formations, and situated like them in a rain-forest climate, the *O. lyallii* formation is distinctly xerophytic; but the mild moist atmosphere has caused production of excessive leaf-surface, just as in the rata forest there is great lateral growth of the *Metrosideros*. Occupying only a narrow zone on the sheltered side of the island, the *O. lyallii* gives place to the rata forest, which certainly seems on that account the better able of the two to withstand the wind, while in its turn on Enderby Island rata gives place on the windward side to *Cassinia* scrub, and this in its turn to tussock.

4. *Lowland Tussock.*

This formation I was only able to examine in two localities—namely, near the landing-place on Ewing Island and between the dunes and the rata forest on Enderby Island; of its distribution on Auckland and Adams Island I know nothing.

The surface of the ground is very wet peat, in many places being actual swamp. Where this occurs the formation varies as to its members, and *Carex* to a large extent takes the place of the grass tussock. The tussock which gives the distinguishing character to the formation as a whole is some species of grass which I had no means of identifying. Ecologically it is remarkable for having constructed large "trunks," on the top of which the grass-plant grows, while its long filiform leaves, which are at first erect, finally arch over and droop downwards on all sides of the "trunk" in great shock-headed masses. Such trunks are more than 1·5m. tall, frequently irregular in shape, and consist of decayed and decaying stems, roots, and leaf-bases; while beneath the green living leaves, which, arching, droop downwards on all sides of the "trunk" to the ground and quite surround it, is a thick layer consisting externally of recently dead leaves, but internally of quite decayed leaves, which surround the "trunk" proper as with a mantle. Such tussocks burn very readily when dry in the summer, according to Captain Bollons, for the most recently dead leaves are frequently quite dry, even when the outside of the tussock is in its normal wet condition. These trunks absorb water like a sponge, and in this manner the living grass above will get a direct water-supply of rain-water, and so be quite independent of the more or less acid water of the boggy ground or of the actual swamp. Similar "trunks" are a frequent feature of the New Zealand landscape, and are formed by *Carex secta*. As the ground becomes more swampy *Carex trifida* appears, taking the place of the tussock-grass.

Between the tussock and the actual sea-shore is a zone of *Poa foliosa*. Probably in this formation are included two quite distinct from one another, a grass-tussock and a *Carex* bog, but the time was too limited to do more than take the above brief notes. A very similar formation seems to be present on Enderby Island, but I have no details, except such as are shown in a photograph, from which it is evident that the tussocks there are of great size. All that part of Enderby Island fully exposed to the wind is occupied by a tussock formation.

5. Pleurophyllum *Meadow.*

Beyond learning that a certain number of most striking and beautiful herbaceous plants grow in company with one

another there, there is little to be found in the writings of those botanists who treat of the Southern Islands, as to the extent, limits, altitude, or edaphic conditions of the plant-formation which these plants constitute, or whether, indeed, such plants do form a distinct society. From the writings of Sir Joseph Hooker it seems clear that at the northern end of Auckland Island—that part alone of the group where his botanical explorations were made—a considerable altitude must be reached before the above-mentioned striking plants are encountered in any number, while he distinctly points out that on Campbell Island, owing to their occurrence at a lower altitude, they form a more striking feature of the landscape. Thus, Hooker writes, "Beyond the wooded region some of the same plants" [the forest trees] "in a dwarf state mingled with others compose a broad shrubby belt, which ascends the hills to an altitude of 800 ft. or 900 ft., gradually opening out into grassy slopes, and succeeded by the alpine vegetation. It is especially towards the summits of the hills that the most striking plants are found, vying in brightness of colour with the arctic flora, and unrivalled in beauty by those of any other antarctic country."

On Adams Island, as mentioned before, strips of treeless hillside reaching to the edge of the water alternate with strips of rata forest. Now, it is just on these treeless pieces of hillside that the formation under consideration appears in that part of the Auckland Group, and so rich in striking flowers is the piece of land at the western extremity of Carnley Harbour that it has received the name of "Fairchild's Garden," a tribute to the memory of the late John Fairchild, who, as captain of the "Hinemoa," did much to advance the knowledge of New Zealand natural history.

The following are the most important members of the *Pleurophyllum* formation: *Pleurophyllum speciosum*, *Pleur. criniferum*, *Celmisia vernicosa*, *Cotula plumosa*, *Cot. propinqua (Compositæ)*; *Ligusticum (Aciphylla) latifolium*, *Lig. (Aciph.) antipodum (Umbelliferæ)*; *Nertera depressa (Rubiaceæ)*; *Epilobium confertifolium (Onagraceæ)*; *Stilbocarpa polaris (Araliaceæ)*; *Acæna sanguisorbæ* var. *antarctica (Rosaceæ)*; *Myosotis capitata (Boraginaceæ)*; *Gentiana concinna*, *Gent. cerina (Gentianaceæ)*; *Bulbinella rossii (Liliaceæ)*; *Scirpus aucklandicus (Cyperaceæ)*; *Aspidium vestitum*, *Asplenium obtusatum (Filices)*; various mosses, liverworts, and lichens. In the gullies is a good deal of *Veronica elliptica*.

Between the *Pleurophyllum* meadow and the stony beach comes a zone of *Poa foliosa*, the before-mentioned tussock-grass with great "trunks," *Carex trifida*, and alternating with these, or in close proximity to them, *Stilbocarpa polaris* and *Ligusticum latifolium*. Probably the *Pleurophyllum* forma-

tion contains some of the smaller grasses, but in midwinter identification of these was impossible.

The soil of this formation consists of a great depth of peat, which at the time of my visit was very wet and sticky, but certainly not so wet as I had expected. The ground, in fact, is neither bog nor even semi-bog, but merely a very moist peaty slope. The forming of peat, even while a plant is alive, is a common-enough occurrence amongst New Zealand cushion-plants. Kirk shows, for instance, how the dense lower leaves on *Raoulia goyeni* of Stewart Island become changed into peat while the upper leaves are performing their usual functions (62, p. 215). In Fuegia also the leaves of living plants are rapidly converted into peat. Darwin writes regarding *Astelia pumila* (23*a*, p. 286), "Fresh leaves are always succeeding one to the other round the central tap-root; the lower ones soon decay, and in tracing a root downwards in the peat the leaves yet holding their place can be observed passing through every stage of decomposition till the whole becomes blended in one confused mass." In the Southern Islands such peat-forming is very plainly to be seen, especially in winter, in certain of the plants, which die down to the ground. Then the leaves of the past year lie rotting upon the surface of the soil, while their bases form great decayed masses many centimeters in thickness round the leaf-bases of the young leaves of *Pleurophyllum criniferum* or *P. hookeri*. In these sheaths of decaying leaves considerable numbers of earthworms are found, and they appear also to be fairly numerous in the peat itself. This will lead to a greater amount of oxygen in the soil than is usually present in peat, and probably there is a considerably less percentage of humic acids; but I have no data on this head. All that can be said is that, notwithstanding the soil is altogether peat, it must be very much more favourable for plant-life than is the peat of an ordinary bog, or even a dry heath.

Since my visit took place in the depth of winter I myself can say nothing regarding the magnificent display of flowers which this spot and the formation in general, if it be indeed a true formation, exhibits during the summer season. However, Chapman gives a most vivid picture of Fairchild's Garden, which is here quoted almost in its entirety: "This place" (16, p. 505) "will now be known by the name we gave it—Fairchild's Garden. It extends from the strait at the north-west end of the island along the shore to the first piece of bush, and thence up to and over the summit of the hill—in all perhaps 400 acres—one of the most wonderful natural gardens the extratropical world can show. No doubt other parts of Adams Island and other places in the group are equally beautiful, but the day we spent here can never be for-

gotten. A peaked rock overhead is 700 ft. above the sea ; the summit rocks are 1,100 ft. by the aneroid. The whole of the ground up to these and beyond them is literally packed with beautiful flowering herbaceous plants. Near the shore the *Ligusticums*, *L. latifolium* and *L. antipodum*, grow in splendid profusion, their stout rhizomes and huge rigid leaves stopping the progress of pedestrians. Along the shore were masses of golden lily (*Anthericum rossii*) in seed. Here, too, grew sweet-scented *Cotula lanata* and its handsome congener *C. plumosa*, both of which are worth cultivating. Over the whole country *Pleurophyllum speciosum* sends up, among huge ribbed leaves 2 ft. long, its spikes of beautiful lilac or purple flowers. These spikes are usually four or five, sometimes eight or ten, in number. The regular imbricating of the large ribbed leaves, so strong as to push aside the rank grasses, renders these plants singularly beautiful. They form deep cups of crisp foliage, which gives way with a crash as you set foot on it." "The next species, *Pleurophyllum criniferum*, was also plentiful. Its leaves are even larger, and, although not so handsome, make it a fine plant, especially as its tall white flower-stalk, sometimes 3 ft. high, covered with button-like brown rayless flower-heads 1 in. across, is a very striking object." "Here, too, we met in immense quantities the most beautiful of all the *Celmisias*, *C. vernicosa*, a little plant with leaves here seldom more than 2 in. long, gleaming like polished nephrite new from the lapidaries' hands, arranged in the most perfect rosettes."

In the middle of winter the *Pleurophyllum* meadow presents a very different aspect, owing perhaps not so much to the absence of flowers as to the winter habit of some of the more important plants. Thus, the huge leaves of *Pleurophyllum criniferum* are altogether wanting, *P. speciosum* only forms comparatively small rosettes—one's feet do not then "crash through the horizontal leaves as though walking on thin ice" (56, p. 220)—while *Bulbinella* is hardly visible at all, the winter buds hidden by the brown bases of the old decayed leaves just protruding above the surface of the ground. To be sure, the great rounded leaves of *Stilbocarpa polaris* and the large dark-green leathery pinnate leaves of *Ligusticum latifolium* still form as dense masses of greenery as in summer, but here the absence of the inflorescence—as large as the head of a man, according to Hooker (46, p. 16)—must make a striking difference between the winter and the summer aspect; but as these plants appear frequently to form an association mixed with little other vegetation of a striking appearance they exercise much influence on the winter physiognomy of the meadow as a whole. Everywhere the ground is dotted with the bright-green winter rosettes of *Pleurophyllum speciosum*

pressed closely against the ground, or numbers of such occur in close proximity. Such rosettes seem to vary considerably in size according to their position with regard to wind and light, those of shady gullies being much larger than those on the hillside. A rosette in the open may be ± 25 cm. in diameter, made up of quite a few leaves, hugging the soil, pressed closely above one another and arching downwards so that their upper surface is convex, a kind of cup being thus formed, with the highest part of its arching leaves as its brim. During rain this cup quickly fills with water, which soaks rapidly through the leaf-bases, bringing fresh rain-water to the roots. The leaves also become thoroughly wetted, their numerous hairs helping to hold the moisture, and it is probable that these also assist in the supply of pure water through their power of absorbing such, as suggested by Diels (27, p. 291). Very frequent all over the formation are large colonies of *Bulbinella rossii*, the green tips of the winter buds just visible above the dark-coloured peat, or the buds are completely hidden by the brown leaf-bases of the previous year's leaves. Such colonies may be several square metres in extent. Trailing over the surface of the ground very abundantly are the long shoots of *Acæna sanguisorbæ antarctica*, with its characteristic pale-green leaves almost or quite glabrous on the upper surface. The small-leaved bright-green *Nertera depressa*, another creeping-plant, is also very abundant. Here and there are grass-like tufts of *Scirpus aucklandicus* and the silvery-leaved *Helichrysum prostratum*, and very frequently associated with these are the shining green winter rosettes of *Gentiana cerina*. The feathery leaves of *Cotula plumosa* are especially noticeable, its thick green stems straggling over large patches of ground. Near the sea *Lomaria dura* is a frequent member of the formation.

Turning now to the life-forms of the endemic members of the *Pleurophyllum* meadow, the most striking feature, and that which distinguishes it especially from the subalpine and alpine meadows of the New Zealand Alps, is the very large leaf-surface possessed by some of the most characteristic plants. Similar leaf-development is seen, however, in some other parts of the New Zealand biological area. In Stewart Island and some of the adjacent islands is *Aralia lyallii*, and in the Chatham Islands the magnificent *Myosotidium nobile*, now almost extinct in the wild state (23, p. 302). In Kerguelen Island also *Pringlea antiscorbutica* may be instanced as a parallel development under similar conditions.

Pleurophyllum speciosum has large leaves pressed close to the ground, and forming, according to Kirk, "a flat rosette 3 ft. to 4 ft. in diameter" (56, p. 220). This position of the leaves must be of great advantage in enabling the plant to

resist the wind, and at the same time it prevents the encroachment of other plants. The winter rosettes, as shown above, are much smaller—25 cm., or about 10 in., in diameter. The leaves have white sheathing bases, which in the largest—*i.e.*, the outermost—measure ± 6 cm. long × ± 7 cm. in breadth, and are densely clothed with long silky hairs pressed closely against the surface. The lamina of such a leaf measures 14 cm. × 14 cm. On its under-surface are about twenty-five very prominent, stout, firm ribs forming the boundaries of channels ± 3 mm. in breadth, filled with a loose tomentum. These channels gradually narrow towards the leaf-base, and are widest above, measuring in one leaf measured 9 mm. The upper surface of the leaf is much channelled with parallel channels, triangular in cross-section and ± 9 mm. wide from ridge to ridge. On the ridges are many transparent moniliform hairs which stretch over the channels. The general aspect of the leaf, so far as its ridges and channels are concerned, is that of the corrugated iron so much used in roofing in New Zealand, and this corrugated appearance must be still more striking in adult leaves. Within the excellent protection afforded by the leaf-sheaths are the bright pale-yellow leaves of the young bud. A cross-section of the leaf shows a thin-walled epidermis, with the outer wall hardly thicker than the inner ones. Beneath this is a one- or, in places, a two-layered large-celled water tissue. The palisade parenchyma consists of rather short, oblong cells, and the spongy parenchyma is extremely loose, the intercellular spaces being of very large size. The roots are large and fleshy, but my notes say nothing as to their direction in the soil.

As for *Pleurophyllum criniferum*, I did not note it at all on either Auckland or Campbell Island, owing to its habit of dying completely to the ground in winter, the tips of the buds alone just projecting above the surface; nor was it until digging in the bogs of Antipodes Island that I met with this, to all accounts, very common plant. The young bud is closely surrounded by a very thick covering of old leaf-bases in various stages of decay. Kirk describes the adult plant as of a very different habit from *P. speciosum*: "The leaves are usually petioled, and from 1½ ft. to 3 ft. in length, suberect and spreading, forming a ring round the erect scapes" (56, p. 220). In texture they are "membranous, but firm, white with thin tomentum beneath" (58, p. 434). Hooker speaks of this plant "as so bulky that an ordinary specimen weighs many pounds" (46, p. 33), and from this latter it may be seen how great a peat-maker this species must be.

Bulbinella rossii, which in summer has numerous thick, spreading, broad leaves 40 cm. long × 3·5 cm. broad, in winter,

as before stated, exhibits merely the tips of the buds, which reach above the surface of the ground to a height of ± 3·5 cm. Such buds, from certain examples measured, are about 11 cm. in length × 2·26 cm. in diameter. They are somewhat conical in shape, and quite sharp at the apex, thus easily piercing the soil. Above they are pale-green, but gradually toning down to yellowish-green or very pale-yellow at the base. The leaves of the bud are fleshy and imbricate closely, thus protecting the interior of the bud, while the bud itself is protected by a thick covering of the dead bases of the old leaves, consisting mainly of the vascular bundles. The rhizome measures probably 2 cm. or so in thickness, and is concealed by the dense masses of thick and fleshy yellow roots, which usually radiate outwards and downwards from the base of the bud.

Stilbocarpa polaris is a noble plant, somewhat after the manner of the Chilian *Gunnera chilensis*. The large rhizome, measuring ± 8 cm. × ± 7 cm., creeps on the surface of the ground. Usually about six fully developed leaves are given off from an ascending portion of the stem. These leaves are ± 6 cm. broad at the sheathing base, which is furnished with a very large stipule ± 18 cm. long × 10 cm. wide at the apex—its widest part. Such stipules in part enclose the interior bud, against which they are pressed tightly by their concave inner surface, and play a most important part in its protection. The petiole, ± 54 cm. long, is thick, but hollow. The leaf-blade is orbicular reniform. It is ± 19 cm. in length, measuring from sinus to apex, and ± 29 cm. broad. These leaf-blades are more or less in the form of a funnel, through the lobes of the reniform base being bent inwards, and so convey any water which falls on them to the roots of the plant. The leaves on both surfaces and the petioles are furnished with many pale hairs 10 mm. in length, which seem to vary considerably in number in various individuals. Drops of water frequently accumulate on these hairs, but whether they can absorb such, as seems to me likely, can only be ascertained by experiment. These hairs remain unchanged in number in plants cultivated under conditions quite different to those of their natural habitat, judging from a plant I have had in cultivation several years in the neighbourhood of New Brighton, on a sandhill at the back of a wall, sheltered from the north-west, and about 1m. from a small stream of water. The leaf-anatomy of *Stilbocarpa* is of some interest. The epidermis on the under-surface of the leaf is attached only to the veins, thus leading to numerous spaces full of air between epidermis and spongy parenchyma. At first there seems to be an almost colourless tissue of rounded cells between the epidermis and palisade, but evidently these become ruptured and the above-

mentioned air-spaces are formed. The lower epidermis contains large numbers of stomata. The upper epidermis consists of a single row of large rectangular cells which are slightly cuticularised. The assimilating portion of the leaf consists of about six rows of palisade parenchyma, each cell about twice as long as broad, succeeded by the smaller and rounder cells of the spongy parenchyma, the lowermost of which project into the above-mentioned air-spaces somewhat after the manner of the assimilating tissue in the air-cavities of *Marchantia*.

Ligusticum latifolium has leaves ± 60 cm. in length, with a very thick stalk ± 2·5 cm. in diameter. The blade is dark-green in colour, very coriaceous, ovate in outline, and bi-pinnately divided into rather broad segments, which are 3- to 5-lobed, each lobe terminating in a needle-like sharp point. These lateral segments are not flat, but bent inwards, thus bringing the two surfaces into proximity, and the upper half into a vertical position with regard to the light. There are fine *Ligusticums* in both the subalpine region of New Zealand and the moist coastal regions of the South Island, but, as is the case with these Southern Island plants, they nearly always exceed their largest New Zealand representatives in luxuriance of growth. The leaf-anatomy much resembles that of *L. antipodum*, described below, but the stereome of the under-surface is replaced by water tissue, and the spongy parenchyma in the middle of the leaf does not seem quite so open as in the allied species. A specimen which I have had in cultivation for some years side by side with *Stilbocarpa polaris*, as mentioned above, has decidedly thinner leaves than those of plants recently collected on Auckland Island.

Ligusticum antipodum is a rather smaller plant than *Lig. latifolium*, and the leaf-blade is cut into a great number of narrow linear needle-like segments, the ultimate ones being ± 2 cm. long. The leaves of this plant are in part dealt with when treating of the subalpine rocks of Campbell Island. There is a thick cuticle on both surfaces. Next to the epidermis is a ring of stereome, which stretches into the interior of the leaf, alternating with broad layers of palisade parenchyma. The arrangement on the under-surface is much the same, but the green tissue is composed of rounded cells. In the centre of the leaf is spongy parenchyma with large intercellular spaces. There are a number of resin-passages. Stomata occur on both surfaces, and they are sunken.

Myosotis capitata, although not endemic in the Southern Islands, is by no means a common plant in New Zealand. In winter it presents semi-rosettes of rather thick, soft, dark-green leaves ± 5·3 cm. × ± 6 mm., covered on the upper

surface with bristly white hairs. The stems, ± 6 mm. in diameter, are prostrate, but with the extremities ascending and forming roundish tufts ± 16 cm. in diameter and 6 cm. from the surface of the ground. The leaves are semi-patent, and frequently recurved at their extremities, and dense enough for one rosette to touch the next. A cross-section of a leaf shows that it is dorsi-ventral, with a non-cuticularised epidermis and large intercellular spaces in the spongy parenchyma.

Gentiana cerina has in winter rather dense rosettes, crowded together, of dark-green imbricating leaves, the four or five outer leaves much larger than those crowded internally. Each rosette is about 3·7 cm. in diameter. Such a plant may measure 10 cm. × 8 cm. In spring the rosettes open out and the new branches spread out radially, with their tips ascending.

Cotula plumosa, which is also found in Kerguelen Land, has stout creeping stems 9 mm. in diameter, by which it spreads over the surface of the ground. They are green on the upper but paler on the under surface, and strongly marked with old leaf-scars, the internodes being ± 1·5 cm. long. Rather stout, cord-like roots, furnished with filiform lateral rootlets, are given off from the nodes. Such creeping stems may be quite without leaves for long distances, and serve both as storage and assimilating organs; in a collected plant 25 cm. were quite bare, but no measurements were taken from growing plants. The leaves in winter are in rosettes at the ends of the creeping stems. The very young leaves in the centre of each rosette are protected by a covering of long silky hairs. The leaves have broad sheathing bases, fleshy in the centre and membranous at the margin, tightly overlapping one another, and this further protects the bud. In each winter rosette there are only a few fully developed leaves. These are pinnate, with the pinnæ much divided, the whole leaf having a feathery appearance, as the specific name implies. The upper side of the leaflet-axis is furnished with about 7 segments—there are, in fact, segments from base to apex; but the lower side has segments only near the apex. The segments also are only divided on their outer side. By this arrangement the various portions of the lamina hardly overlap at all. There is also a gradual transition from pinnæ without any lower segments to those with 2–3 segments on the lower side, the two nearest the base having no lower segments. Such a leaf as the above measures 14·2 cm.; the lamina 7·5 cm. × 4·3 cm.; the pinnæ 1·8 cm. × 10 mm. The sheath is 3·5 cm. long × 5·5 cm. wide (when spread out). The remainder of the petiole is stout, almost flat on the upper and rounded on the under surface,

tapering slightly from below upwards, and 2·5 mm. thick × 5 cm. broad towards its centre. The leaves are pale-green in colour. On the blade and sheath are a few straggling hairs. Numerous roots are given off from the leafy portion of the plant, but only a few from the naked creeping stems, and these roots will function especially as holdfasts. *Cotula propinqua* is intermediate between the above and *Cot. lanata*, so need not be further dealt with here.

Celmisia vernicosa has the leaves in densely crowded rosettes 3·1 cm. in diameter in one case measured; but they must very frequently be much larger than this, for the leaves, according to Hooker (47, p. 136), may reach the length of 4 in. (10·1 cm.). Below are the remains of many dead leaves. The leaves are bright-green, highly polished and shining, extremely coriaceous, and with margins recurved. The rosettes frequently form large patches. *Veronica benthami* is described in the part relating to Campbell Island. The remaining plants (spermaphytes and pteridophytes) of this formation are more or less common in New Zealand, and need not be dealt with here.

Perhaps that which is most noticeable about the *Pleurophyllum* meadow when comparing it with related ecological formations in New Zealand—as, for instance, a western subalpine meadow in the South Island—is the very different colouring of the flowers. In the subalpine meadow is the dazzling white of *Ranunculus lyallii* or the various species of *Celmisia*, the yellow-throated but otherwise white *Ourisia macrocarpa*, white gentians, white *Ligusticums*, the yellow-, white-, or cream-coloured *Senecio scorzonerioides*, and amongst the shrubs are white-flowered *Olearias* and *Veronicas* (these sometimes with a shade of lilac) and yellow *Senecios;* in short, with hardly an exception, all amongst flowers in any way conspicuons are white or yellow.* In the *Pleurophyllum* meadow, on the contrary, are: *P. speciosum*, with disc-florets purple and ray-florets purplish-white; *P. criniferum*, with flower-heads deep-brown; *Lig. latifolium*, with large umbels of reddish flowers; *Lig. antipodum* of similar colour to its ally; *Celmisia vernicosa*, with rays white and disc-florets deep-purple; *Bulbinella rossii*, orange-coloured; *Veronica benthami*, deep-blue; *Gentiana cerina*, white with stripes of bright-red; *Myosotis capitata*, violet-blue fading to purple; *Epilobium confertifolium*, pink. Moreover—and this is a very significant fact—with the exception of the *Myosotis*, a rare plant in New Zealand, the whole of the above are endemic, and they are also the dominant plants

* The alpine flora of Australia, as evidenced by the plants of Mount Kosciusco, have, according to Mr. J. H. Maiden, "an enormous preponderance of white flowers," while yellow flowers come next in number (75A, p. 29).

of the formation. Certainly there are some yellow flowers; *e.g.*, *Cotula plumosa* and perhaps *Bulbinella rossii* should be here included. The gentian is described by Kirk as occasionally white. *Helichrysum prostratum* is also found in New Zealand, and it has white flower-heads. The flowers of *Stilbocarpa polaris* I have not seen in the living state; they are described by Kirk as "one-quarter of an inch in diameter, yellow, waxy, shining, with purple centres" (66, p. 215). The remaining plants have all small and inconspicuous flowers.

Thus, the difference so far as colour is concerned between a *Pleurophyllum* meadow and an allied formation in New Zealand proper is most marked. As to how such differences have come about is discussed under another head.

7. *Subalpine Meadow.*

The portion of subalpine meadow visited by me was that just above the forest-line at Camp Cove, in the south of Auckland Island. Here the ground is at a gentle slope, and much cut up by gullies, which are full of scrub. The soil, as elsewhere in the Southern Islands, consists of peat, always more or less saturated with water, and in places so wet that such might be designated semi-bog. This differs considerably in its plant-members from the drier part of the meadow. The dominant meadow-plant is the large coarse-leaved tussock-grass *Danthonia bromoides*, which gives a feature to the landscape, as pointed out by Kirk (56, p. 221), similar to that afforded by its relative, *Danthonia raoulii*, of the Canterbury mountains. The meadow-scenery, in fact, to quote a very familiar instance, much resembles that on either side of the West Coast Road, in Canterbury, between Parapet Rock and the road-crossing at Cave Creek. Dotted about all over the meadow are bushes of *Dracophyllum longifolium* of about the height of an average man, the xerophytic structure, stiff needle-like leaves arranged semi-vertically and confined to the ends of the shoots, enabling this forest-plant to hold its own in the open in the full blast of the subalpine wind. *Cassinia vauvilliersii* is also plentiful, in its case the small tomentose leaves and strong stiff branches being in harmony with its environment. *Coprosma cuneata* is also plentiful, and it, in addition to small leaves of xerophytic form, creeps close to the ground, and in consequence receives much shelter from the tussocks and erect shrubs. On the surface of the ground large patches of various species of moss are abundant, and on the stems of the shrubs are various lichens.

The semi-bog, which forms a distinct plant-association, can at once be distinguished from the rest of the meadow by the presence of the large, round, bright-green, dense cushions of *Phyllachne clavigera*, a bog xerophyte of the typical form

of many other antarctic cushion-plants. *Coprosma repens* covers the wet ground with its rather succulent prostrate stems and small green leaves, and the needle-leaved *Cyathodes empetrifolia* is very common. Growing associated with the above are patches of *Astelia linearis subulata*, the short, stiff, vertical, green portion of the leaf rising above the ground for about 11 mm. This plant spreads into large colonies by means of its long wiry stems, which creep just beneath the surface of the ground. These stems are covered thickly with old decayed leaf-sheaths, and with these and the roots form extremely dense mats 3 cm. or more in depth. The stem proper is marked with old leaf-scars, and measures only 1·5 cm. or less in diameter. Just before issuing from the ground the stem branches into two or three leafy shoots, each furnished with 2–3 green leaves. Such leafy shoots, being quite close, form a rather dense turf. The leaves are $\pm$ 2·1 cm. long, and consist of a pale-coloured sheathing base, which is rather longer than the vertical or semi-vertical shining green subulate lamina. There are a few hairs on the sheath and occasionally at the base of the lamina, otherwise the green portion of the leaf is quite glabrous. The assimilating tissue consists of round cells close together, except on the upper surface, where this tissue is broken into by a rather broad layer of large-celled water tissue reaching to the centre of the leaf. The epidermis is moderately cuticularised, and the stomata are just below the cuticle. This plant differs very considerably from the type, which is altogether larger in all its parts and has leaf laminæ, linear, 5·4 cm. long $\times$ 5 mm. broad, coriaceous, so bent upwards as to make a channel on the upper surface of the leaf, and the midrib and edge of leaf covered with adpressed brown chaffy hairs. The rhizome is also much stouter and more densely clothed with decayed leaves. Mixed up with the above-mentioned plants are various mosses, liverworts, and lichens, which find a suitable habitat on the wet soil, very conspicuous being the beautiful white masses of *Cladonia retipora* or an allied species. Growing through the carpet of *Cop. repens* or forming large patches to itself is the filmy fern *Hymenophyllum multifidum*, a striking testimony to the constant moisture of the atmosphere. Growing in this situation it has altogether a different habit to that which it bears as a forest plant. From the slender wiry rhizome creeping amongst the mosses or turf pass upwards numerous erect very dark-brown wiry stipes from 2·9 cm. to 5 mm. in length. The dark-green leaves, which look almost black from the dark colour of the midribs, arch downwards parallel with the erect stipes, and may bury their apical portion or even more amongst the accompanying mosses. The pinnæ likewise are curved vertically downwards,

and the segments, crowded together and with their edges more or less recurved, reduce the leaf-surface into a very small compass indeed compared with the normal form, which has its pinnæ expanded horizontally. Plants of this form cultivated in the moist chamber of the Canterbury College Biological School have their new fronds not in the least degree curled up and of a bright-green, contrasting strongly with the almost black curled fronds. Such young fronds are at first erect, with their pinnæ plagiotropous, but finally the stipes bend so as to bring the whole surface of the frond into a horizontal position.* There are other plants belonging both to the wet and dry parts of the subalpine meadow, but my notes only mention the above, for they were taken most hastily. Amongst some of the important plants omitted are *Drosera stenopetala*, *Astelia linearis* (the type), *Juncus scheuzerioides*, *Gaimardia ciliata*, *Oreobolus pumilio*, *Lycopodium fastigiatum*, *L. varium polaris*, and *Schizæa australis*.

8. *Subalpine Scrub.*

The difference in species between the formation of the open meadow and that of the more sheltered gullies and depressions is very instructive, for in the latter position occur those constituents of the forest which have a less marked xerophytic structure than those which can exist as plants of the meadow, and which in the latter situations certainly become more stunted, but otherwise are of perfect vigour. Thus, in the gullies are found some of the arborescent forest-plants, small trees no longer, but now dense shrubs, forming, so far as form goes, a typical "subalpine scrub," such as might occur above the forest-line of a New Zealand mountain. *Metrosideros lucida* and *Panax simplex* are both present, but now no taller than the accompanying *Suttonia divaricata*. Here, too, is the prostrate *Coprosma cuneata*, and most likely *Cop. ciliata* and *Cop. parviflora*. Scrub such as this is even more difficult to penetrate than is the western subalpine scrub of a South Island mountain, and in consequence, as it was late in the afternoon when I reached the subalpine meadow, and as these gullies full of scrub had constantly to be crossed, I had no time to see the vegetation of a mountain-summit in the Auckland Islands, the place *par excellence* where any novelties might be expected to occur.

II. Campbell Island.

General Remarks.

Campbell Island lies in latitude 52° 33′ S. and longitude 169° 09′ E., and is distant 145 miles south-east of Auckland

* By March, 1904, the new fronds of the curly leaved form were identical with those of the type.

Island and 330 miles south by east from the South Cape of Stewart Island. It was discovered in 1810 by Frederick Hazelburgh, master of the brig "Perseverance," who described the island as being thirty miles in circumference, and the country mountainous (90, p. 417).

The general configuration of the island can be seen from the accompanying map. Although the mountains are not quite so high as those of the Auckland Islands, they are somewhat steeper and more rocky. The coast-line for the most part consists of abrupt cliffs not unlike those near the entrance of Akaroa Harbour, and it is described by Hooker as, "Iron-bound as that of St. Helena, the rocks assuming even a wilder and more fantastic form." Buchanan's drawings (9, pl. xxxviii.) give some idea of the island as seen from the sea.

The "Hinemoa" stayed the whole of two days, so I was enabled to see a good deal of certain parts of the island, ascending the first day to the summit of Mount Honey, 568m., the highest point on the island, and on the second day crossing over Lyall's Pyramid from Perseverance Harbour to North-east Harbour. My notes are therefore confined to the country in the east of Campbell Island, much of which, as may be seen further on, is no longer in its primitive condition, owing to fires and the grazing of sheep for some seven years past.

CLIMATE.

From Mr. Gordon, manager of the sheep-run on Campbell Island, I have received very many valuable details respecting the climate. This, on the whole, seems very similar to that of Auckland Island. There is the same lack of sunshine and similar frequent gales accompanied by driving rain and sleet, especially in spring and autumn. The driest period, if we can speak at all of such in these Southern Islands, is from November to May. Sunshine is most frequent during the summer months, but even when bright at sea-level there is generally more or less fog on the higher peaks. The snowfall at sea-level is very slight, Mr. Gordon having noted 76 mm. as the heaviest fall during a period of seven years. Such snow comes in blasts from the south-west, while these gales are frequently accompanied by hail. During five winters the thermometer at sea-level only registered 2° Fahr. of frost. In what I designate the "subalpine region" the frost is certainly much stronger than the above. Although on the day when I climbed Mount Honey there was no frost at sea-level, above a certain altitude the ground was frozen so hard that I could not dig up the plants in order to examine their subterranean organs; but there was no general covering of snow, only a few patches here and there. Such frost without a pro-

tective covering of snow subjects these plants to comparatively severe conditions—much more severe, in fact, than any to which the plants of lower levels are exposed. As for rain, really heavy rain—according to Mr. Gordon—is not very frequent; usually it is a fine drizzle. In short, there must be a great number of rainy days, but no excessive annual rainfall.

GEOLOGY.

According to Hector (40, p. 737), Campbell Island is a volcanic mass, but has the peculiar feature of having, slightly above sea-level, the original rock-formation on which it is founded. On the north and south it presents fantastic peaks and precipices carved out of rocks of the same character as those which form Otago Peninsula. Towards the southern end it is traversed by Perseverance Harbour east and west, which is by a moderately high saddle connected with West Harbour. On the north and south of this rift are frowning cliffs and peaks of basaltic lava-sheets; but at the sea-level there is an exposure, both on the east and west coasts of the island, of the Upper Cretaceous rocks, with chalk flints and fossil wood, such as is found in New Zealand in the Upper Amuri series. These have been brought to the surface-level together with the volcanic outburst, as they are injected and interstratified with dykes and tufa rocks of the same kind. The wonderful mystery of the occurrence of fossilised dicotyledonous wood in the far south latitude of Campbell Island is therefore thrown entirely out of the distribution of plant-life in Tertiary times, and must be referred to the Cretaceous epoch. At an altitude of 800 ft. clear evidence of the existence of a true corrie and moraine of the first order was obtained, but it is purely local, and is the only evidence of former glacier-action observed.

According to Filhol (35*a*, p. 261), Campbell Island is formed of a band of limestone and lavas. "The limestone band is jammed between two coral dykes, the overflow from which has partly covered it. This layer, the thickness of which is about 70 metres, has evidently been formed in a very deep sea. Fossils are absolutely wanting in it, and micrographic sections have only enabled me to note the presence of *Globigerina*. This limestone, which is of a yellowish colour, is not met with again in any part of New Zealand. Its upper surface at those parts where it is not covered by the lava is not overlaid by any terrestrial deposit." "It is perfectly certain that the geological age of the island, constituted as we now see it, corresponds to the epoch of the appearance of the volcanic eruptions." "The limestone which the eruptions of Campbell Island have brought up, or which perhaps by its fracture has formed a passage for the lava, must have been

formed during Post-pliocene periods—that is to say, in the epoch during which New Zealand possessed its last great geographical extension. It was not, therefore, before the very end of the Pliocene that Campbell Island as it now exists appeared above the surface of the sea." This account of Filhol's differs very materially from that of Hector; as to which is the more correct I can offer no opinion.

THE PLANT-FORMATIONS.

The plant-formations consist, so far as I was able to ascertain, of the following: (1) Stony shore; (2) scrub; (3) lower tussock meadow; (4) subalpine tussock meadow; (5) *Rostkovia* formation; (6) subalpine rocks. There are doubtless also lowland swamps, maritime-cliff vegetation, running-water vegetation, while possibly certain combinations of plants which I did not meet with may constitute formations or associations. Indeed, here as elsewhere for these Southern Islands my account and classification of the plant-formations is but provisional. Most of the life-forms of the endemic members of the formations have been dealt with in the part of this paper referring to Auckland Island, but one or two more common in Campbell Island than in the Auckland Group, as well as those endemic to the island under consideration, are dealt with when describing the formations of which they form a part.

1. *Stony Shore.*

An extremely rapid examination was made of the stony shore along the south of North-east Harbour. Here *Ligusticum latifolium* comes right on to the stones of the beach, accompanied by *Stilbocarpa polaris*, which does not approach so near to the water's edge. Creeping over the stones is *Cotula lanata*, and growing here and there amongst them is a small grass, in general appearance not unlike *Danthonia australis* (11, pl. xxxi.), but which I cannot identify until a specimen in cultivation flowers. Wherever rocks are present are the cushions of *Colobanthus muscoides*. Altogether, this formation is very similar to that of the stony sea-shore of Auckland Island.

2. Dracophyllum *Scrub.*

There is no arborescent growth to which one can with truth apply the term "forest" on Campbell Island. The scrub may vary considerably in height according to the degree of shelter it receives, but everywhere there are only shrubs, and not low trees with bare trunk and spreading crown beneath which one can walk, as in the forests of Auckland Island. Most probably the absence of forest depends upon the slightly stronger winds and much less shelter

to be found than in Auckland Island, dependent upon the configuration of the ground and to some degree upon the smaller size of the island. On Antipodes Island, as will be seen further on, the scrub attains still smaller dimensions, and has almost reached the vanishing-point, while on Macquarie Island there is no scrub at all (39). These islands, then, as a whole, afford an instructive example of how arborescent plant-formations even in a rain-forest climate may be inhibited by frequent and violent winds and their place taken by meadow growths, which, notwithstanding the wind, are so stimulated by the moisture as to be of very great luxuriance.

The arborescent constituents of the scrub are the following: *Dracophyllum longifolium*, *Dracophyllum* sp. (not identified) *(Ericaceæ)*; *Coprosma cuneata*, *Cop. ciliata*, *Cop. parviflora (Rubiaceæ)*; *Suttonia divaricata (Myrsinaceæ)*. From this it appears that this formation is closely allied to the subalpine scrub of the Auckland Islands.

Seen at a distance, as from the deck of a ship in either of the harbours, the *Dracophyllum* scrub of Campbell Island presents an even surface, and puts one in mind of the *Leptospermum* scrub so common on poor soil in many parts of New Zealand. It occurs on both sides of Perseverance Harbour, especially near the entrance and on the north side, where, however, it has been much burned. The long comparatively flat valley leading inland from the head of North-east Harbour is filled in many places with scrub, which ascends thence to a considerable height up the slopes on both sides of this valley. Generally speaking, the shrubs grow closely together, and are of the most extremely dense habit of growth. There is nothing in my experience of quite a number of dense forest and scrub growths in New Zealand more difficult for one to penetrate than this *Dracophyllum* scrub of Campbell Island. In many places one has to crawl beneath the stiff masses of branches, but in other cases this is quite impossible, and one has to scramble over the tops of the shrubs. Happily, here and there open spaces occur, especially in the neighbourhood of watercourses, where there are dense masses of herbaceous plants, and such spots afford breathing-places.

The dominant constituent of the scrub is the unidentified species of *Dracophyllum* mentioned above.* It varies considerably in height, averaging perhaps 1·5m., but is frequently of lower growth. It possesses numerous densely growing, strong, erect, rather brittle branches covered with almost black bark. These branches are again much branched, and furnished near their extremities with a close mass of short leaves. The secondary branches pass from the main stem at an acute angle, curving slightly inwards. The ulti-

* Perhaps a form of *Dracophyllum scoparium*, Hook. f.

mate branchlets pass upwards from the stem at a very acute angle, thus bringing the leaves into an almost vertical position. The leaves are short and narrow, ± 14 cm. in length × 1 mm. in breadth, concave and pubescent on the upper surface and convex on the under-surface. They are so densely crowded together as frequently to touch one another. Where this scrub was tallest a stem measured 8 cm. or 9 cm. in diameter at 90 cm. from the ground. Mixed with the *Dracophyllum* is *Suttonia divaricata*, but the amount present of this dense shrub varies in different places. Where the scrub is tallest there is mixed with it a small proportion of *Dracophyllum longifolium*. Where the scrub becomes more open *Coprosma cuneata* is a constituent, knee-deep, and so, much more luxuriant than on the wind-swept hillside; also, there are large patches of *Lomaria procera*. The leaves of *Dracophyllum longifolium* are much more spreading than those of its vertical-leaved ally, and the two species can easily be distinguished from one another at some distance away. The scrub frequently merges into the *Danthonia* meadow, and the two formations thus become intermingled, or occasionally the large grass may be a constituent of the scrub proper. In the former case we have probably a line of tension between scrub and tussock meadow. Such mixture of tussock and scrub was especially noticeable on the north side of Lyall's Pyramid, and is described at some length further on.

The floor of the scrub varies both in the density and character of its plant-covering according to the openness of the scrub and the moisture-content of the soil. Where the scrub is extremely dense there is little on the ground beyond a carpet of dead *Dracophyllum* leaves, sometimes 15 cm. in depth. If the bushes are a little further apart *Aspidium vestitum* makes its appearance, in company with *Lomaria procera*, and seedlings of the different shrubs are common. With still greater openness of the scrub *Lomaria procera* becomes taller and more abundant, growing in company with stunted *Coprosmas* and small plants of *Dracophyllum* sp. Here, too, rather tall clumps of *Lycopodium varium* are a conspicuous feature, while where the ground is unoccupied by other vegetation is a carpet of mosses, liverworts, and lichens. Very frequently some of these mosses or liverworts form mounds, on which grows abundantly the filmy fern *Hymenophyllum multifidum;* or mosses, liverworts, and ferns may be mixed up with the prostrate branches of *Coprosma cuneata*. In this part of the formation *Epilobium linnæoides* is always present to a greater or lesser extent.

Sometimes the various *Coprosmas* and *Suttonia divaricata* are more abundant than the *Dracophyllum*, and in sheltered places attain a height of 1·7m.

The conditions of life for the plants of the floor of this formation are quite different from those to which the scrub as a whole is exposed, and which regulate its distribution and define its components. Where one sits down within the shelter of the scrub the air is quite still, while the wind can be heard plainly whistling overhead.

That comparatively open spaces exist within the domains of the scrub was pointed out above when speaking of its density. Such are occasionally met with on the southern slopes of Lyall's Pyramid, and increase in number as North-east Harbour is neared. Here are associated together many of those fine herbaceous plants which were described when treating of the *Pleurophyllum* meadow of the Auckland Islands, and probably this association of plants is a formation distinct from the scrub, owing its existence to greater moisture in the ground and protection from the scrub. In such situations the great leaves of *Ligusticum latifolium*, with their stout petioles, are more than knee-deep. Where the ground becomes a little wetter still is *Pleurophyllum speciosum*, its leaves larger and less decayed than in the meadow formation. These same plants, and, most of all, *Stilbocarpa polaris*, follow the many watercourses which cut into the hillside, and grow luxuriantly in the running water. On the banks of such streams the small buttercup, *Ranunculus subscaposus*, is abundant. This plant so far has only been found in Campbell Island. According to Hooker it is quite rare (46, p. 5), for during the Ross expedition only one specimen was discovered. Hooker subsequently referred an allied New Zealand buttercup to this species (48, p. 7), but Kirk very rightly separated this latter from *R. subscaposus* in the "Students' Flora," giving it the name of *R. foliosus* (66, p. 14). I collected a number of living plants of *R. subscaposus*, and two are now growing well on the Canterbury College rockery, one of which bloomed on the 25th October. The leaves of *R. subscaposus* are somewhat cordate in outline, trifoliate, with leaflets cuneate at the base and three-lobed above. Both petiole and lamina on both surfaces are densely covered with appressed whitish* hairs. The petiole is stout, and 2·2 cm. to 3·8 cm. long in the plants examined; the lamina is 2 cm. × 1·8 cm. The petals are yellow, with a broad band of brown, which is most noticeable at the back of the petal.

The transition between tussock meadow and scrub, mentioned above, and which may be designated "tussock scrub," consists of tussocks of *Danthonia bromoides* ± 1·6m. tall and

* In the "Flora Antarctica" the hairs are described as of a tawny-yellow colour.

large bushes of *Coprosmas* mixed with *Aspidium vestitum;* but these two latter are not so tall as the tussock. At distances of about every 12m. the ground is cut by deep gullies having running streams in their bottoms, their sides covered with scrub and their bottoms filled with a dense mass of *Ligusticum latifolium*, *L. antipodum*, and *Stilbocarpa polaris*. The *Danthonia* tussock has been already described. As for the *Coprosmas*, they consist within of dense masses of bare interlacing twiggy branches. On the periphery alone of such bushes is the actual green part of the plant, and this leafy zone only penetrates into the plant for perhaps 7 cm. at most. Looking from the north side of Lyall's Pyramid at the slopes bounding the opposite side of the flat valley filled with tussock and tussock scrub, they are seen to be curiously marked below by brown tussock meadow on the ridges, while very irregular-shaped masses of scrub or tussock scrub define the main and tributary gullies. Above all this is an even formation of sub-alpine tussock meadow. Passing through the tussock scrub, and keeping at a uniform height on the hillside, crossing in the meanwhile gully after gully full of vegetation as described above, wetter ground than the average is here and there encountered. Such contains a different assemblage of plants to the tussock scrub proper, and should really be described under another head, but for convenience' sake it is dealt with here. It is especially instructive in showing how a change in the water-content, even in a region where all the normal soil is fairly saturated with water, will at once bring about a marked change in the vegetation. On such a spot, which was specially examined, the *Danthonia* tussock, although still present, was much reduced in size; *Pleurophyllum speciosum* and *Pleur. hookeri* were very plentiful; *Lomaria procera* carpeted the ground in many places and gave a character to the whole. The common *Dracophyllum* was dotted about, but here again a characteristic plant of another formation was much reduced in size, the plants being less than 30 cm. in height; in other places the carpet consisted of a small *Juncus* (*J. scheuzerioides ?*), liverworts, mosses, *Coprosma repens*, *Helichrysum prostratum*, *Ligusticum antipodum*, tufts of *Lycopodium varium* or *Lycopodium fastigiatum* rising up here and there; while everywhere *Coprosma* bushes, these much stunted, were scattered about. Large breadths of *Hymenophyllum multifidum* and hummocks of mosses and liverworts about 30 cm. in height were abundant, while the ever-present lichens, both foliaceous and fruticose, gave colour, their whites, yellows, and browns contrasting finely with the many hues of green. In some places water trickled over and in others stones cropped out of the wet peaty ground. Finally, there were many large clumps of *Bulbinella rossii*.

3. *Lower Tussock Meadow.*

Buchanan writes (9, p. 398), "The whole coast-line is rugged in the extreme, although inland large flat areas may be seen apparently covered by grasses and indicating rich pasture. This appearance, however, on closer examination, is found to be deceptive, as but few grasses exist, and a coarse wet cyperaceous pasture prevails, which would prove worthless for feed except for cattle of a hardy breed that would stand the rigours of the climate. There is no doubt, however, that on the lower levels, where soil can accumulate, a rich though coarse vegetation exists; but the land is so spongy and wet that the finer grasses cannot thrive. The extreme wetness of the soil is shown by the fact that wherever a plant is dug out with a knife the hole immediately fills with water, and an indication is thus obtained of the treatment such plants should receive when it is attempted to grow them in a drier climate."

However true the above may be as regards certain portions of the island, it certainly does not in the least apply to the parts visited by me, and extending from sea-level to the tops of two of the hills, one the highest on the island. It may be that there are low-lying tracts occupied chiefly by *Carex*, but so far as my investigations went, except where there was scrub, grasses and not cyperaceous plants abound, and the tussocks which densely clothe the mountains from summit to base are of grass and not of sedge, while small grasses of various kinds are by no means uncommon. Moreover, such tussocks are at the present time feeding 4,500 sheep, and this on at most only one-half of the island. As for the wet nature of the ground, it certainly does contain a great deal of moisture, but even in the middle of winter water cannot be generally wrung out of the peat; nor did any hole made by me in digging for plants fill with water, as, *e.g.*, in the bogs of Chatham Island.

The lower tussock meadow forms a more or less distinct zone on the hillsides from the sea-level to a height perhaps of 150m., where it is succeeded by a second zone of meadow, to which I have given the name "subalpine tussock meadow," above which comes a third but narrow zone where *Rostkovia gracilis* is the characteristic plant, while above and through this latter is the final zone, that of the rock-plants.

In no place where I was able to examine the lower tussock meadow was it in its virgin condition. Everywhere on Mount Honey, where at one time this formation must have been typical, have sheep grazed for some years, and their effect has been so marked that it is dealt with under another heading. But even now it is not hard to form a very fair

idea of what the virgin formation was like, for although many plants are destroyed their remnants remain. Some few places still approximate to the primeval condition, and—most important of all—introduced plants have not as yet appeared in any quantity, and so increased enormously the difficulty of determining the character of the virgin formation.

The dominant plant is a tussock-grass with long narrow filiform leaves, probably a species of *Poa*—perhaps, indeed, identical with the meadow tussock of Antipodes Island, referred by Kirk to *Poa anceps*. My specimens, collected in midwinter, were too poor for identification; even Mr. D. Petrie, whose knowledge of the New Zealand grasses is so thorough, could make no definite statement as to the species.* By Mr. Gordon, of Campbell Island, it is called "silver-tussock," and that name will serve admirably for the present.

With the silver-tussock is mixed occasionally a little *Danthonia bromoides*, and everywhere in the open spaces between the tussocks are the great colonies of *Bulbinella rossii* which attracted the attention of Hooker so that he wrote (46, p. 73), "It" [*Bulbinella*] "covered the swampy sides of the hills in such profusion as to be distinctly visible at a full mile from shore." Similarly, the allied but smaller *B. hookeri* clothes many hillsides in the lower mountain region of the South Island with sheets of yellow. In these same open places *Pleurophyllum speciosum* was very frequent, while the dark-green *Aspidium vestitum*, the brown-coloured *Lomaria procera*, and prostrate bushes of *Coprosma ciliata* were common. These bushes are in some places flattened close to the ground; in other places, where the shelter is greater, they may be about 1·9m. long × 90 cm. wide × 90 cm. tall. Their surface is sometimes flat, as if cut by shears, or at other times marked by long longitudinal ridges. They form extremely dense, large, flattened, pale-green hummocks, with bare, much-interlacing, rather thick, twisted branches beneath, looking not unlike stems of lianes; but the dense green surface, composed of quite small leaves, is at most 9 cm. or 10 cm. in depth. In some cases reversion-shoots are given off from the base of the plant, in the shelter and dim light of its interior, having very much larger leaves than those of the adult, and being almost identical with those of seedlings. In one seedling examined the stem was densely pilose; leaves ovate-oblong with rounded or cuneate base, pale-green, ciliated, a few hairs sometimes on the upper surface of the lamina, but always on the midrib. Petiole densely hairy,

* Since writing this Mr. Petrie informs me that the Antipodes Island tussock was the one he had referred to *Poa chathamica*, but that he, and probably Mr. Cheeseman also, now considers it to be a new and unnamed species.

3 mm. long; lamina 1·6 cm. × 1·1 cm., veins distinct. No pits, so common in *Coprosma*,* were noticed on the back of the leaf.

With the bushes of *Coprosma ciliata*, *Aspidium vestitum* is frequently mixed. Here and there, growing through the bushes or mixed with the tussock, were the rather shaggy naked stems of *Veronica benthami*, a shrub confined to the Campbell and Auckland Islands. These stems are marked with many old leaf-scars, but above are quite green. The leaves are crowded together at the extremities of the branches; they are thick, rather soft, narrow obovate-oblong in shape, dark-green, and their margins are edged with a pale-coloured tomentum. In size they are about 3·5 cm. × 1·4 cm. With regard to the light, the surfaces of the lower and larger leaves are horizontal or frequently arch downwards somewhat. The structure is that of a typical dorsi-ventral leaf. Nearer the apex of the shoot the leaves are smaller than those below, broader in proportion to their length, and loosely imbricating. The flowers are in racemes, which lengthen considerably during flowering, each flower subtended by a very large green leaf-like bract. The petals are a most clear violet-blue marked by very narrow lines of a still deeper blue.

Where the ground becomes wetter the character of the formation changes. There the surface is carpeted with the brown fronds of *Lomaria procera*, amongst and over which trailed the silvery-leaved *Helichrysum prostratum*. Through the *Lomaria* grow tussocks of *Carex appressa*.

The following extract from my notebook affords some idea of a general view of a piece of lowland meadow: "Large breadths of *Lomaria procera* mixed with stunted *Carex appressa*, low bushes 16 cm. tall of *Coprosma parviflora*, little conical cypress-like shrubs of *Dracophyllum scoparium* 30 cm. to 60 cm. tall dotted here and there, yellow tussock waving in the breeze everywhere except where *Lomaria procera* is abundant." These little *Dracophyllum* shrubs have naked dark-coloured stems for half or less than half their height.

From the above it may be seen that there are two distinct associations of plants included under my term "lowland tussock meadow," more or less sharply separated from one another by the amount of moisture in the ground: on the drier ground silver-tussock is dominant, and on the wetter a fern—*Carex* association. All the same, many of the meadow plants are common to both associations, and appear to thrive equally well either in the drier or moister ground. It must

* Greensill, N. A. R.: "Structure of Leaf of certain Species of *Coprosma*." Trans. N.Z. Inst., vol. xxxv., pp. 342, 355. 1903.

be borne in mind that the term "dry" is here merely comparative.

The soil of the formation as a whole consists of spongy peat, which is elastic underfoot. The surface is at first gently sloping, but becomes steeper as one proceeds up the mountain-side. Except within the gullies, and these in consequence filled with scrub, all the hillsides of Campbell Island must be much wind-swept; indeed, it seems evident that wind is here, as on the uplands of Auckland Island, the determining factor as to whether arborescent or grassy growth shall predominate.

4. *Subalpine Tussock Meadow.*

The presence of this formation, and also those next to be considered, probably depends upon the greater severity of the climate, arising from frosts being much more severe and of very much longer duration than at a lower level, the frequency of such frost unaccompanied by snow, the greater exposure to winds—these at times must be of the most extreme severity—and, finally, the smaller amount of sunshine and the almost constant presence of mist. The soil of this formation is similar to that of the lower tussock meadow.

The dominant plant, as in the subalpine meadow of Auckland Island, is *Danthonia bromoides*, in many places growing very thickly. Between the tussocks are large quantities of *Pleurophyllum hookeri*, in winter its leaves projecting above the ground to a height of $\pm$ 7 cm., and the leaf-blades of the previous year, 17 cm. $\times$ 7 cm., forming a decaying mass spread out radially round the plant. Creeping over the surface of the ground are in many places considerable breadths of *Coprosma repens*, while *Helichrysum prostratum*, *Nertera depressa*, *Stellaria decipiens*, *Epilobium linnæoides*, *Epilobium confertifolium*, and *Lycopodium fastigiatum* are common. As in the lowland tussock, *Aspidium vestitum* and bushes of *Coprosmas* give an additional character to the physiognomy of the formation. Where the ground is wettest *Sphagnum* appears, and in conjunction with this bog-moss are a number of other plants, some of which are truly bog-plants, while others are prominent members of very different formations. Of the above plants the most striking are the large, bright-green, hard cushions of *Phyllachne clavigera*, patches of *Hymenophyllum multifidum* with curled-up fronds, as previously described for the subalpine meadow of Auckland Island, *Coprosma repens*, much-stunted *Coprosma* bushes, *Pleurophyllum hookeri*, *Pleurop. speciosum*, *Epilobium confertifolium*, large patches of *Bulbinella rossii*, and very many lichens.

Of these plants the only one which needs detailed treatment here is *Pleurophyllum hookeri*, which is by far the most

common representative of that genus in the subalpine region of Campbell Island. This species was originally described, and also figured, by Buchanan in 1884 (10, p. 395); later on Kirk gave it the MS. name of *P. gilliesianum*, and still later described it under the name of *P. hookerianum*, J. Buch. (58), a slip which he corrected in the "Students' Flora," where the plant is described as *P. hookeri*. According to Kirk (58, p. 435) the adult-leaves are 6 in. to 10 in. long by 3 in. to 4 in. broad, white on both surfaces with silky, lax, or close tomentum, and, appressed to the ground, form a rosette. From each plant from one to three scapes are given off, 15 in. to 24 in. tall, which bear—from Kirk's plate of this species—some 20 hemispherical or almost globose heads $\frac{3}{4}$ in. in diameter. The ray-florets are few or wanting, and are of a deep lurid-red or reddish-purple.

In winter a clump of *Pleurop. hookeri* may occupy a space of $\pm$ 46 cm. $\times$ $\pm$ 30 cm., and consists of a number of short rosettes (buds) surrounded by the dead leaf-blades of the previous year, as stated further back. The leaves of the largest rosettes are semi-erect, or those with very short leaf-apices quite erect, and densely imbricate, especially at the base, the plant in this condition reminding one rather of the habit of *Celmisia verbascifolia* than of a *Pleurophyllum*. Surrounding these living leaves is a dense mass of old decayed leaf-bases sopping with water. Stripping off these dead leaves, in one particular instance the column of living leaf-bases measured 2·26 cm. in diameter, but with the sheath of dead leaves the diameter of the whole was 6 cm. In another case measured the dead and living leaf-bases taken together were 23 cm. in circumference. The winter leaves are broadest at the base—3·5 cm.; but the margins remain almost parallel for most of the length of the leaf, finally converging into an acute point 3·3 cm. long at 5·5 cm. from the apex. The sheathing bases are extremely silky, with long hairs pressed upwards against the surface of the sheath. Such hairs are $\pm$ 2·3 cm. long, very silvery and glistening, especially those which cover with a thick loose mass the back of the sheath. The leaf as a whole is rather flaccid, and coloured pale-green where exposed to the light. The margin and adjoining portion of the sheath is membranous, but elsewhere, and especially towards the centre, it is fleshy. The rootstock is $\pm$ 2·4 cm. in diameter. The roots are numerous, thick, and fleshy. Seen from a distance the rosettes are of a whitish-green colour.

5. *The* Rostkovia *Formation.*

At a certain altitude on a Campbell Island mountain the formation now to be described forms a very distinct zone, which is especially noticeable since its physiognomy differs

altogether from that of the tussock meadow, owing its characteristic stamp to the numerous yellowish-brown (in winter) tufts of *Rostkovia gracilis*, 28 cm. in height, which form considerable patches, but not appearing as tall as they really are owing to their waving in the wind. Growing side by side with the *Rostkovia* in large quantities is *Pleurophyllum hookeri*, and this, when in flower during the summer, will doubtless be the most striking feature of the formation. Large green cushions of *Phyllachne clavigera* are everywhere abundant, some of them of great size—*e.g.*, 66 cm. × 40 cm. and 20 cm. high—the extremities of the shoots rooting in the decayed leaves now turned into peat, and which make up the chief bulk of the cushions. Each main shoot of this interesting plant branches near its extremity, giving off several short shoots 1·5 cm. in length, the upper 6 cm. of which are densely clothed with very small imbricating green leaves. These final shoots are all pressed tightly together, and make apparently a solid convex mass. The leaves are very thick and coriaceous, expanded at the base, convex on the under (outer) surface, but slightly concave on the lower half of the upper (inner) surface, but flat on its upper half. They are not quite erect, but the globose tips point slightly outwards. This plant, then, is of that typical bog xerophytic form, as pointed out before, common to many New Zealand, Fuegian, and Andean plants, and which reaches its climax in the vegetable sheep of New Zealand, which, however, are not bog-plants, but denizens of sunny alpine rocks.

Other common members of the *Rostkovia* formation are *Luzula crinita*, *Helichrysum prostratum*, a species of *Cardamine* spoken of further on, one or two small grasses, *Polypodium australe pumila*, *Ranunculus subscaposus*, *Abrotanella rosularis*, *Hymenophyllum multifidum* (the mountain form), while everywhere are mosses, lichens, and, most of all, liverworts.

The *Rostkovia* formation usually occurs among the stony *débris* at the bases of the cliffs near the summits of the hills. This *débris*, the result of that weathering which has formed the steep faces of the cliffs, is for the most part mixed to no small extent with the peat which has accumulated from the decay of many generations of plants. Here and there large rocks are lying on the ground covered with crustaceous lichens, white and yellow. In other places are patches of *Sphagnum*, and water oozes frequently out of the ground and trickles over its surface.

Where the stony *débris* has little or no peat mixed with it spermaphytes are almost absent, but there are numerous lichens and mosses. In such situations, however, here and there are the bright-green rosettes of a species of *Cardamine*

6·5 cm. in diameter. The leaves are dark-green, pinnate, with three leaflets on each side, thick and fleshy, the petiole deeply channelled and broadening gradually to the base. The largest leaflets measure 5 mm. × 6 mm. The outermost leaves are flattened against the stones, the remainder spreading upwards and outwards at about an angle of 45° from the vertical. The buds appearing on cultivated plants at the end of October are sheltered by the innermost leaves. A transverse section of a leaf shows a thin-walled epidermis on both surfaces, having also equally abundant stomata both on the upper and under surface, a two-layered palisade, and an open spongy parenchyma. This structure is remarkably hygrophytic for a plant whose characteristic station is stony *débris*, and it eloquently testifies to the abundant moisture of the atmosphere. The closeness, also, with which the plant hugs the soil will protect it much from the action of the wind, and the water of the stony substratum will be quite different in its humus-acid content from that of the wet peat.

6. *Subalpine Rocks.*

The summits of the hills of Campbell Island are very rocky. The final peak of Mount Honey is composed entirely of rocks, much weathered, as may be well imagined in a situation so exposed. The summit of the ridge of Lyall's Pyramid consists for a large part of steep rocky faces; in fact, in many places such may be called cliffs. In these rocks are frequently hollows, small gullies, ledges, irregularities, and crevices, in or on which are often considerable quantities of peat; in fact, peat is always present wherever it is possible for such to lodge. In many cases the rocks drip with water, or sometimes they are dry; but even where this is the case the rock, owing to the excessive moisture of the climate, offers by no means an unfavourable station for certain forms of plant-life. In a dry climate rock-vegetation may be scanty or perhaps altogether wanting in places, but there are hardly any spots entirely unsuitable for plants.

The rock-plants proper are few in number. Leaving out of the question certain mosses, liverworts, and lichens, they are: *Ligusticum antipodum (Umbelliferæ); Colobanthus subulatus (Caryophyllaceæ); Abrotanella rosularis, Abrotanella spathulata (Compositæ); Hymenophyllum multifidum* (subalpine form); *Polypodium australe pumila (Filices);* one or two small unidentified species of grass (*Graminaceæ*). This is a very small list, while the whole of the species, moreover, occur in other formations, and in the case of the *Ligusticum* and *Hymenophyllum* in great profusion.

An exact account of the distribution of the vegetation of

the subalpine rocks of Campbell Island with regard to the physical conditions afforded would be an interesting study, but here only a few details can be given regarding certain specified spots.

On the face of a precipitous rock facing north-west, not far from the summit of Mount Honey, at an altitude of about 538m., the vegetation consists of lichens, mosses, small cushions of *Colobanthus subulatus*, and stiff rosettes of *Abrotanella rosularis*. In the chinks of the rock grows the curious little fern *Polypodium australe pumila* and *Ligusticum antipodum*, here very much smaller and with stiffer and more coriaceous leaves than when occurring at a lower level as a meadow-plant.

On the dry wind-swept rocks of the actual summit of Mount Honey, at an altitude of 568m., are various species of lichens, some mosses, *Polypodium australe pumila*, *Ligusticum antipodum*, *Phyllachne clavigera*—here a rock-plant, just as the closely related bog-plant *Phyllachne colensoi* frequently is in the Southern Alps—a small unidentified grass, and *Luzula crinita*.

On Lyall's Pyramid, at an altitude of about 153m., facing south, a rock dripping with water is covered densely with mosses, liverworts, *Hymenophyllum multifidum* (or perhaps here it was *H. villosum*) to a depth of 9·3 cm., and through this grows the small *Polypodium* and *Ligusticum antipodum*. This has the bases of the leaves densely sheathed with old leaf-bases. The leaves arch upwards and outwards radially, with the result that many of the stiff needle-like pinnæ are almost vertical and others horizontal. Each primary leaflet finally arches downwards. In a position such as this the conditions, although on a rock, are not very different from those of a bog, except that the water will be distinctly more pure.

A rich vegetation occurs in the hollows between the rocks where there is plenty of soil and moisture. Here, as described above, is a dense carpet of mosses, &c., through which are growing *Rostkovia gracilis*, prostrate *Coprosma cuneata*, *Ligusticum antipodum*, *Helichrysum prostratum*, *Ranunculus subscaposus*, *Celmisia vernicosa*, *Celmisia chapmanni*.

In wet sheltered hollows of the cliffs on the north side of Lyall's Pyramid *Ligusticum antipodum* is very abundant, its leaves usually pressed closely against the rock.

Steep rock-faces are covered for large breadths by the subalpine form of *Hymenop. multifidum* and a species of *Cladonia*, but where the rock offers a flat surface and peat can form in which moisture can lodge *Ligusticum antipodum* forms an almost close formation, mixed with *Phyllachne clavigera*, stunted *Coprosma cuneata*, *Coprosma repens*, and a small grass,

the whole growing through a most dense and thick carpet of mosses, &c.

But the richest rock-vegetation of all is found in those sheltered hollows large enough for peat to have accumulated in abundance. In such spots is a rich vegetation of the large herbaceous plants common to the Southern Islands. *Pleurophyllum speciosum* and *Pleur. hookeri* are abundant; *Veronica benthami* and *Celmisia chapmanni* both grow most luxuriantly; *Ranunculus pinguis* and *Azorella reniformis* are more or less plentiful. But I had no time to take a list of all the plants of such a station, which, so far as I can recollect, contained representatives of most of the herbaceous plants of the island. And it is easy to see how such a station as this is very favourable for plants, since the very conditions are here present which experience has found essential for the cultivation of difficult alpine plants—viz., shelter, a porous soil, abundance of pure water, perfect drainage—conditions which are more acceptable possibly to *Pleurophyllum*, &c., than those offered in some of its usual habitats.

Before leaving this formation something must be said regarding the life-forms of the rock-plants endemic to Campbell Island, or those which have not yet been dealt with.

Abrotanella rosularis has wiry stems, creeping at first, but finally erect, covered more or less with old dead leaves. The terminal leafy portion of the shoots measures 1·3 cm., and consists of spreading imbricating leaves, the uppermost of which form a stiff dark-green rosette about 1·3 cm. in diameter, the individual leaves so spreading outwards as to have their upper surface horizontal. The individual leaves are linear or linear-lanceolate, sheathing at the base, which is frequently purplish-rose-coloured, coriaceous, concave on the upper surface. Hooker describes the plant as "a small, densely tufted, moss-like plant." The leaf-anatomy presents certain xerophytic features. There is a thick cuticle on the upper surface provided with slightly sunken stomata, a dense palisade parenchyma, frequent resin-passages, and a certain number of mucilage-cells. On the other hand, the stomata of the under-surface are not sunken, and there is an abundant spongy parenchyma.

Polypodium australe pumila is a most abundant plant on the subalpine rocks. The very small fronds are given off at close intervals from the rhizome, which is densely covered with brown scales. These fronds are very thick and coriaceous, small but somewhat variable in size; the blade measured in certain specimens 7 mm. × 4 mm., 7 mm. × 2 mm., 5 mm. × 1·5 mm., and is frequently more or less buried in mosses or liverworts, which accentuates its small size; the stipes measured from 5 mm. to 1·5 mm. Grown in

moist air the plant is rapidly developing rather larger leaves, which are narrower in proportion to their length. Such measure 11 mm. × 3 mm., and stipes 4 mm. long, but probably such fronds have not attained their full size. However, judging from the experiment as it proceeds, it seems unlikely that fronds will be developed to match the typical form of *P. australe*.

Celmisia chapmanni forms large rosettes of glossy dark-green leaves, reaching a size of 14 cm. in diameter and 12 cm. in height. The more external leaves radiate outwards, at the same time arching downwards, while the short not fully developed internal leaves are vertical. The leaves are not nearly so varnished as those of *Cel. vernicosa;* they are thick and coriaceous, ± 8·8 cm. × ± 9 mm., and have a short, thick, fleshy base. The dead leaves remain attached to the plant, rapidly rotting and turning into peat. The epidermis of both surfaces is strongly cuticularised; extremely strong bands of stereome surround the vascular bundles; the spongy parenchyma consists of large cells containing a great number of oil-globules. The stomata on the under-surface are sunken.

Colobanthus subulatus forms small, convex, round, dense, soft cushions ± 5 cm. in diameter. At the ends of each shoot are 6–8 stout green leaves ± 7 mm. in length, the base membranous and sheathing and the apex acicular. The upper surface is channelled. Below the terminal green leaves the shoot-axis is clothed with the old leaves of previous years.

III. The Antipodes Islands.

General remarks.

The Antipodes Islands are situated in latitude 49° 41′ south and longitude 178° 43′ east (90), and consist of one island much larger than the remainder, named Antipodes Island, and some seven much smaller islands and rocks, of which Bollons Island is the only one of any importance. The group is 490 miles east-south-east from the South Cape of Stewart Island, and 400 miles east-north-east from Campbell Island.

Antipodes Island, according to Captain Fairchild, is about two miles and one-third in length from east to west, and one mile and one-third in breadth from north to south. The highest point is Mount Galloway, 402m., but a large part of the island is at a considerable height above sea-level. From the base of Mount Galloway in an easterly direction lies a considerable tract of flat land sloping very gently towards the sea. The "Hinemoa" sailed right round the island, and so its aspect as viewed from the sea could be noted. The coast-line is precipitous and rocky, the rocks black in colour or marked with many broad patches of a white crustaceous

lichen, which at a close view gives the steep rock-faces the appearance of having been painted white. Above the cliffs, when they are not very high, or where the coast is not rocky, stretch upwards steep slopes densely covered with brownish-yellow tussock. These slopes are shallowly seamed by very steep gullies filled with patches of *Aspidium vestitum* and *Coprosma* scrub, which at a distance look like black bands stretching through the tussock.

Bollons Island is an extremely precipitous island rising out of the sea to a height of 140m. A landing can only be effected in the very finest weather. Captain Bollons, who has once landed on the island, tells me that it is clothed in places with tussock and small scrub similar in appearance to that on Antipodes Island. There are many petrel-burrows and sea-hawk rookeries.

Regarding the geology of the group, Hector writes (40, p. 737), "Antipodes Island is the result of four distinct centres pouring out scoria and basaltic lavas with enormous deposits of volcanic breccia, which proves the great local violence of the eruptions. The erosion of the coast-line has been very slight considering the friable nature of the rock, so that the eruptions must have occurred in a very late geological time, coincident probably with that of the Auckland peninsula." Kirk (56, p. 228) describes the main island as being "somewhat the shape of a ham." "The eastern extremity, corresponding to the shank of the ham, appears to have been formed by a narrow lava-stream." "The island is simply the crater of an extinct volcano, and would be roughly circular in shape were it not for the lava-stream which has been already mentioned." "The crateriform portion of the island is surrounded by low rounded hills on three sides. It is not quite certain whether the whole island is volcanic. Some distance from the landing-place I noticed what appeared to be a mass of finely bedded sandstone, but could not get near enough to determine its precise nature. Most of the rocks observed were basaltic." Captain F. W. Hutton, who visited Antipodes Island in January, 1891, informs me that he considers it the remains of a submarine volcano, and that probably the island has never formed a part of the mainland of New Zealand at the time when the problematical island-continent included what is now the Kermadec Group in the north, and perhaps New Norfolk, the Chatham Islands in the east, and the remainder of the Southern Islands in the south—Macquarie Island perhaps excepted.

With regard to the climate of Antipodes Island, I should imagine that it is very similar to that of the other Southern Islands—cloudy skies, frequent showers, a mild temperature in winter but a cool summer, and, finally, furious gales and

squalls with hail or sleet, of which winds the nature of the arborescent plants bears abundant evidence. During my all-too-short visit it drizzled at intervals, with the wind blowing in squalls, between which occasionally the sun would peep out for a few minutes.

Although sealers and whaling-ships had frequently visited the Antipodes Islands, and H.M.S. "Victoria" had called there in November, 1865, it was not until Kirk published an account of their plants that anything definite was known regarding the botany of the group. But prior to this important publication some general facts were known about the vegetation, for Captain J. Fairchild had reported, as a result of his visit in 1886, that the whole island was covered with a coarse grass, and that no bushes or wood of any kind was found (90), meaning by this latter that there were no trees or large shrubs.

Reischek, the ornithologist (89, p. 386), who visited Antipodes Island in January, 1888, states regarding the vegetation that it "consists of tussock-grass with some cotton-plants, aniseed, and veronicas intermixed with it, and that there is no bush whatever. The tussock-grass all grows in humps, except on the tops of the hills, where there is shorter." The "cotton-plants and aniseed" would be *Pleurophyllum* and *Ligusticum*, while probably the "veronica" would be *Coprosma*, though there is no reason why *V. benthami* might not be eventually found on the island.

Kirk's account is quite short, occupying only four pages octavo, and includes a list of the plants which he had collected or noted—viz., forty-one species of spermaphytes, of which two are introduced plants, and twelve species of pteridophytes. Two endemic species new to science were discovered—*Senecio antipoda*, a quite remarkable plant, and *Gentiana antipoda*, which is related to the other gentians of the Southern Islands. It is impossible to say how much of the island Kirk examined, but, judging from his remarks and bearing in mind the difficult nature of the ground owing to the closeness of the large tussocks, he could hardly have penetrated to any great distance from the landing-place.

Chapman, however, who visited the island on the same day as Kirk, reached the summit of Mount Galloway, and describes it as "clear ground, matted with *Pleurophyllum* and low-growing *Ligusticum*. Owing to fog we failed to see a clear lake* said to exist there. There was a good deal of flat ground up there, which was literally alive with albatroses."

Owing to the short time at my disposal, I was only able to

* This lake was reported by Mr. W. Dougall as covering an area of 13 or 14 acres (14, p. 200).

examine the vegetation of the flat ground extending from the base of Mount Galloway northwards, the ridge forming the south-eastern boundary of this flat ground, the slopes on both sides of this ridge, the gully through which the northern stream flows, and the tussock slopes and rocks on the northern side of the island near the landing-place. It will be seen from this that the whole western side of the island and the greater part of the southern side is still botanically unexplored, and this comprises somewhat about one-half of the island, small as it is. All the same, I think there will hardly be any other plant-formations of any importance than those described below, unless it be a swamp formation in the west, at that point marked "Swampy" in Fairchild's map (33); and perhaps the actual summit of Mount Galloway may have a different combination of plants to the meadow formation described below. During a long summer's day, if the weather kept fine, it would be easy for an active man to travel over the greater part of the island, especially if he had an assistant to carry some of the impedimenta. The lake on the summit of Mount Galloway requires a careful examination for water-plants.

THE PLANT-FORMATIONS.

Speaking generally, the vegetation of Antipodes Island, when viewed from an eminence, seems to consist of dense masses of tussock-grasses, so that one might at first glance be apt to consider the whole plant covering as but one formation, which might be designated "tussock meadow," or some such name. But on a closer examination it is clearly to be seen that the plant covering is by no means a uniform one, and that different conditions of water-content in the soil, of shelter from the constant fierce winds, of proximity to the sea or to "bird-rookeries" have led to the differentiation of sufficiently well-marked plant formations and associations, some of which are separated from one another by sharp boundaries and do not mingle to any extent, although they have many species in common; that is to say, such formations present themselves as distinct groups of the vegetation rather from the manner in which their members are combined than from these being different species. Thus we have here an instructive example of how from the same materials several distinct combinations can be made by slightly different surroundings, the poverty of the flora emphasizing the selective power of the habitat.

The plant-formations which I noted as forming more or less distinct societies are the following: (1) Maritime rocks; (2) tussock meadow, divided into three sub-formations—(*a*) maritime tussock slopes, (*b*) flat tussock meadow, (*c*) inland tussock slopes; (3) scrub; (4) bog; (5) inland rocks (6 and 7) stream and swamp.

1. *Maritime Rocks.*

The surface of the rock may be quite flat or more or less vertical. On the flat rocks, in the crevices, or on the ledges are frequently considerable accumulations of peat. As to moisture, although the surface of the rock must vary considerably in this respect, it seems probable, considering the wet climate, that even the vertical faces of the rocks will usually be covered with moisture. Ecologically this formation is the same as that already described for the Auckland Islands under the heading "Coastal Rocks," but floristically, so far as is at present known, there are some considerable differences, for here the well-known New Zealand *Apium australe* occurs, while the grass which gives such a character to the Auckland Island cliffs—*Poa ramosissima*—and also the rosettes of the *Plantago*, are absent.

The closeness of the formation depends upon the steepness of the rocks. Where they are quite vertical their vegetation — lichens and mosses excepted — occupies only the crevices or ledges; but where they are flat or the ledges large a more or less dense covering occurs, which, if present in sufficient quantity, might quite well be considered a distinct formation, closely related ecologically to what I may designate "coastal turf," and which is a frequent formation in certain parts of the south coast of the South Island of New Zealand and of the small islands in Foveaux Strait.

The following, copied almost verbatim from notes taken on the spot, gives some specific examples of the maritime-rock plant-formation: "Growing just above high-water mark on the flat rocks is *Tillæa moschata*, mixed with small tufts of *Festuca scoparia*. Over steep faces large green masses of *Tillæa* hang downwards, mixed with a small form of *Apium australe*. In crevices of the bare rock are round cushions of *Colobanthus muscoides* of a vivid green. In a sheltered nook on a flat rock, with a high perpendicular rock behind, is a dense mass of *Scirpus aucklandicus* 1·35m. × 60 cm. in area, and growing through it *Tillæa*, *Apium*, and *Festuca*; while just at the junction of this combination of plants and the bare rock are several small cushions of *Colobanthus*. Such masses of *Scirpus*, *Tillæa*, and *Apium* are about 15 cm. deep." The driest of the perpendicular rocks or cliffs are covered densely with a white crustaceous lichen. Where the cliffs are quite glistening with moisture a dark-green shining moss grows upon their steep faces, forming cushions after the manner of and in company with *Colobanthus muscoides*. Such moss-cushions are wringing wet. On the flat summit of a low cliff creep the stout green stems of *Cotula plumosa*, with a carpet of *Tillæa moschata* on the seaward side. Behind this first zone of coastal-turf or rock plants, which clothe the rocks

and cliffs or fill their hollows, comes a second zone, consisting for the most part of *Poa foliosa*, mixed with a variable amount of *Carex trifida*. This same zone, which merges into the maritime tussock slope, occupies the flat summit of the cliffs, down the precipitous faces of which the long, green, flat leaves of the grass hang in thick masses.

2. *Tussock Meadow.*

The tussock meadow is by no means a uniform formation, but varies so much in composition and physiognomy according to the position in which it grows that it is here subdivided into three sub-formations; indeed, I am not sure but that these latter should be considered as distinct plant-formations.

(a.) *Maritime Tussock Slopes.*

From the steeply sloping bank of soft, wet, and spongy peat rises up a dense mass of tussocks about 1·5m. in height growing upon thick trunks so very closely together that it is not easy to walk between them. These tussocks consist chiefly of a species of grass which I could not identify, and is possibly the same as the "silver-tussock" of Campbell Island. Kirk mentions *Poa anceps* as occurring on Antipodes Island, and it may be that this is the grass referred to. At any rate, it is by far the commonest grass on the island, and it is the characteristic plant of the tussock meadow as a whole. Mixed with this tussock are others, but occurring to a much smaller extent, of *Poa foliosa* and *Carex trifida*. Where these tussocks grow closely there is room for no other spermaphytes, unless they grow on the summit of the tussocks' "trunks"; but where they are a little further apart, so that spaces clear from tussock occur, there is a varying amount—in some places, indeed, a great abundance—of *Ligusticum antipodum*.

(b.) *Flat Tussock Meadow.*

Perhaps this should rather be classed as a heath, for ecologically it seems much more to resemble this latter than it does a meadow. The badly drained soil, poor in nourishment, the abundance of lichens and lycopods, the stunted bushes of *Coprosma*, and the semi-xerophytic ferns certainly point to its classification as a heath; but, on the other hand, the presence of a grass as the dominant plant seems to mark the society as a meadow.

Taking a general view of the meadow, and casting the eye for some distance over its flat expanse, yellow tussocks 50 cm. or so apart are seen waving in the breeze, and alternating with the very dark, almost black, spreading fronds of *Aspidium vestitum*, so that it appears at first glance as if only these two species were present, as it is, indeed, they alone

which stamp the physiognomy of the meadow. Where the tussock and fern are not so dense *Ligusticum antipodum* occurs in such quantity as to add bright-green patches of colour in an equal proportion with the yellow grass or dark fern. But if the eye be cast not so far afield, then the pale-green of the *Acæna*, climbing amongst the tussock or fern, and the withered brown fronds of *Pteris incisa* add other features to the general picture.

The soil of the meadow consists on the surface of rather loose brown peat, so soft that a stout stick can be thrust deeply into it. Water cannot be wrung out of the surface-soil, but this can be quickly kneaded into the consistency of porridge. The surface is very uneven, the dead trunks of grass or fern forming mounds on which many plants grow, while between the living tussocks are numerous slight depressions and deeper hollows. Everywhere the ground is occupied by vegetation, which, although not rich in species, consists of many individuals.

Amongst the most frequent plants are the following: Foliaceous and fruticose lichens, mosses of several species, liverworts, *Lomaria alpina*, *Pratia arenaria*, *Acæna sanguisorbæ antarctica*, *Luzula crinita*, *Gentiana antipoda*, *Epilobium linnæoides*, *Hypolepis millefolium*, *Epilobium* sp.—the *E. alsinoides* of Kirk's list (56, p. 230)—*Stellaria decipiens angustata* (66, p. 57), *Lycopodium fastigiatum*, *Lycopodium varium*, *Asplenium bulbiferum*—a form with thick leaves—*Hymenophyllum multifidum*, *Helichrysum prostratum*, *Coprosma repens*, and *Coprosma cuneata*.

The carpet of small plants clothing the peaty ground is not a uniform one. Notes taken in various parts of the meadow show that sometimes one plant and sometimes another is the leading one for the particular station; for instance, in some places the thick-leaved form of *Asplenium bulbiferum* is abundant, in others is much *Hymenophyllum multifidum*, with its fronds curled up and arching downwards until partly buried amongst the mosses or liverworts which grow in its company.

In the shelter of a grass-tussock *Lycopodium varium* $\pm$ 25 cm. tall is frequent; below it is erect and furnished with many yellowish-green imbricating leaves, while above its brownish spikes arch downwards. *Ligusticum antipodum*, as well as the tussock and *Aspidium*, also plays its part as a shelter-plant, its leaves spreading out radially, with their surface more or less horizontal, such plants averaging about 78 cm. in diameter and 22 cm. in height.

One or two quotations from my notebook may assist in giving a picture of the floor of the meadow: "Here on ground where the tussocks and fern are more distant, growing in the

hollows, are large quantities of *Gentiana antipoda*, numerous fruticose lichens of various species, *Coprosma repens*, *Acæna*, *Luzula crinita*, many fine foliaceous lichens, and large patches of the filmy fern, this latter sometimes 8 cm. tall." "Here is tussock growing, mixed with *Aspidium vestitum* and *Luzula crinita*. In the hollow near by are mosses, lichens, hepaticas, *Acæna*, *Pratia arenaria*, and *Lomaria alpina*." "Here is a large plant of *Ligusticum antipodum* not nearly so tall as the tussock, and so in partial shelter. On one side of this two tussocks, on the other side one half-dead tussock with lichens and *Luzula* and *Hymenophyllum* growing on its trunk and *Aspidium* growing through it, while the neighbouring hollow is filled with *Hymenophyllum* and lichens growing together. In parts of the meadow the tussock and *Aspidium* become much smaller or are almost altogether absent, and here *Lomaria procera* takes its place, its arching fronds almost parallel to the ground, raised but a few inches above its surface, their pinnæ bent a little upwards, the surface of the frond thus becoming semi-horizontal.

The summer aspect of the meadow must be very different from that described above. The tender green of the two abundant ferns, *Pteris incisa* and *Hypolepis millefolium*, will then add a feature quite wanting in winter, while the difference will be still more marked when the great umbels of *Ligusticum antipodum* are in full bloom.

The only endemic plant to be dealt with here is *Gentiana antipoda*. This has a short root-stock $\pm$ 5 mm. in diameter, which is usually at first decumbent, but finally erect for $\pm$ 7 mm.; from this pass decumbent branches, except at apex, $\pm$ 2·7 cm. $\times$ 2·5 mm. in diameter, closely covered with leaves, except near base. The leaves are vertical in their lower but spreading somewhat in their apical half. The vertical part and back of leaf is pale yellowish-green, but the more spreading part is bright-green. They are $\pm$ 5·4 cm. $\times$ $\pm$ 8·5 mm., slightly fleshy, and linear-spathulate or ligulate in shape. The margins are slightly recurved; the upper green part of the leaf is flat and the lower pale part is channelled. The root is of considerable length, and runs more or less horizontally in the soil. A seedling plant 1·35 cm. tall had a root 4·9 cm. long.

A cross-section of a leaf shows a strong cuticle furnished with conical protruberances equalling the thickness of the cuticle. There is a palisade 5 or 6 cells deep of rather short, broad, rounded, oblong cells about 1½ times as long as broad. The spongy parenchyma is loose, having many intercellular spaces. Kirk (69, p. 341) describes two forms of this species under the names *pallida* and *rubra*. The former is stated to have yellow stems and white flowers, and the latter red stems

with white flowers vertically streaked with red. He also describes the plant as perennial, but I think that most probably it is a biennial. Mr. H. J. Matthews, who cultivated this plant, agrees with me in this conclusion.

(c.) *Inland Tussock Slopes.*

In many respects this sub-formation is similar to that last described, but it contains very much more *Stilbocarpa polaris;* and, in addition, the following plants, which, if they occur at all on the flat meadow, are very rare: *Urtica australis*, *Poa foliosa*, *Senecio antipoda*, *Carex appressa*, and rather large bushes of a species of *Coprosma*—perhaps *C. ciliata*. Unfortunately, I neglected to bring away specimens of this latter plant, but it did not seem the same to me as *C. ciliata* of Auckland and Campbell Islands. The ordinary grass-tussock and *Aspidium vestitum* are much larger than are the same species in the flat meadow, owing probably to the better drainage of the slope. The soil is, generally speaking, drier than that of sub-formation (*b*), and shallow gullies change the conditions with regard to wind, in consequence of which a transition between "scrub" and "tussock slope" is there present. In certain places the ground is more or less bare, where the giant petrel has its "rookeries," and in consequence the soil must be much enriched with its manure.

As one painfully toils up the hillside huge plants of *Aspidium vestitum* 1·5m. tall, with stout trunks and spreading fronds, are encountered growing in company with tussocks equally large of *Poa foliosa* and *Carex appressa*, amongst which are dotted large flat-topped bushes of the *Coprosma* mentioned above or small colonies of the large-leaved nettle *Urtica australis*. The "trunks" of these tussocks are of great size, and when the plant dies large mounds of peat remain. Seen at a distance the *Aspidium* makes large black-coloured blotches on the hillside. Frequently fern, tussock, and scrub give place to great masses of *Stilbocarpa polaris*, its large rhizome creeping on the surface of the ground, and the large leaves, quite close together, raised aloft on their exceedingly stout petioles, the whole mass of leaves and leaf-stalks forming dense thickets. One colony of this remarkable plant measured 11m. × 3m., but those met with further on, of which no measurements were taken, were of much larger size. With the *Stilbocarpa* are mixed few other plants, the rhizomes occupying the ground and the leaves excluding the light. The *Coprosma* bushes are of equal height to the fern and tussock of grass or sedge. The leafy top is about 1·8m. in diameter and almost semi-globular in shape, its ultimate twigs extremely dense and leafy for a depth of 16 cm. The leaves are very numerous, but quite small and narrow—about 7 mm.

long × 1·9 mm. broad. This combination of *Poa foliosa*, *Aspidium vestitum*, *Coprosma ciliata*, *Urtica australis*, and *Stilbocarpa polaris* appears to form a distinct association, its presence depending upon the greater amount of shelter that it receives. This protection from wind is also much increased for its internal members when such an association becomes established, the tussocks themselves affording much shelter. Right on the summit and most exposed part of a ridge, seated on the ground under the lee of a tussock, the storm could be heard raging overhead, but where I sat was quite calm.

Where the hillside is less sheltered the vegetation consists of the common meadow-tussock, *Aspidium vestitum*, and *Pteris incisa*, with the ever-present *Acæna* climbing in thick masses over the grass and fern. Here both fern and tussock, although still of considerable size, are of much smaller dimensions than in the association described above, and this part of the subformation is but a continuation of the flat meadow.

The bare ground manured by the giant petrel (*Ossifraga gigantea*) is occupied by another association of which the endemic *Senecio antipoda* is the dominant plant. Growing in its company are very thick masses of *Acæna*, which is frequently mixed with *Pteris incisa*. *Stellaria decipiens angustata* is also common. *Senecio antipoda* much more resembles the common European groundsel in outward appearance than do any others of the herbaceous section of this genus in New Zealand. It is a very curious fact that, both here and in Chatham Island (23, p. 268), in situations frequented by certain sea-birds there should be an endemic species peculiar to such stations. So far as *Cotula featherstonii* of Chatham Island is concerned, its growing in ground near the holes of mutton-birds is recognised by the settlers who live in its vicinity, and from them it has received the name of the "mutton-bird plant." I do not see why rich heavily manured soil should not be just as much a factor in determining the life-form of a plant as illumination, moisture in the air, wind, or any other ecological factor, and to find two plants each of distinctly luxuriant growth growing under very similar conditions is suggestive, to say the least.

Senecio antipoda is a stout herbaceous plant of upright growth. It has a rather thick main stem, hollow in old plants, which gives off numerous lateral branches from its upper portion, and these are furnished above with many usually large, spreading, membranous, green leaves. These when fully grown are broadly spathulate in outline, the upper and expanded half of the leaf being deeply pinnatifid, while the segments are again deeply cut, especially on their lower margin. Such expanded portions of the leaves measure 9·5 cm. × 7·7 cm. The lower half of the leaf is entire or

toothed—this might be called a winged petiole—and has the margins almost parallel; in the leaf in question it measured 6 cm. × 1·9 cm. The leaves vary much in size according to the size of the plant, as also somewhat in shape. The upper surface of the leaf is green and almost glabrous in adult-leaves, but the under-surface is more or less tomentose with loose cobwebby hairs, the tomentum being much more abundant in young than in old leaves. The margins are recurved, and on the under-surface of the leaf is a prominent midrib, which gradually broadens towards the base, and which may attain to a thickness of 5·5 mm. The tomentum plays an important part in protecting the bud during winter. The leaves round the growing point are tightly pressed together, and remain quite vertical until of a considerable size—6·8 cm. × 4·6 cm. in one case measured. These young leaves are tomentose on the upper surface of the broad midrib, and especially towards their base, which tomentum, becoming entangled with that of the under-surface of the contiguous leaf, binds all the leaves round the growing point into a firm weather-resisting mass not easily penetrated by moisture.

3. *Scrub.*

On the sheltered sides of the hills the scrub becomes somewhat higher and more abundant than that mixed with the herbaceous plants of the tussock slopes. Such scrub occurs, so far as I could see, in every sheltered gully on all the hills of the island, and not merely, as stated by Kirk, on Mount Galloway (56, p. 228). Seen from the summit of the ridge on the east side of the island, the scrub is of a dark-green colour, and descends in long broad lines down the hillside. Only a few minutes were available for examination of this formation, but where I entered it, it consisted of *Coprosma* plants, 1·5m. tall, growing very closely together and possessing long thin trunks about 3 cm. in diameter at most, so far as I can recollect, and dividing into two or three vertical branches, which give off numerous dense twigs, these forming a flat leafy crown about 16 cm. or less in breadth and perhaps 8 cm. in depth. Certain lichens and mosses grow on the stems, which are otherwise bare, and where the shrubs are not close together there is some *Epilobium linnæoides* and *Lagenophora forsteri* on the ground. This is a most incomplete account of this interesting formation, the only representative on Antipodes Island of the forests of the Auckland Group or the extensive scrub of Campbell Island.

4. *Bog.*

Towards the centre of the flat meadow occur many almost circular patches where the soil is much wetter than that of

the meadow, and where genuine bog-conditions prevail. Such patches can be recognised at a glance (see Pl. XX.) by the difference of their vegetation, which has a physiognomy of its own, quite distinct from that of the meadow which surrounds them, and from which the bogs are divided by quite a sharp line. If a number of such bogs be examined it will be found that, though they do not all contain their members in exactly the same proportion, there is a most striking similarity between them all, separated though they are by large patches of meadow.

That which at first glance most distinguishes the bog from the meadow is the large amount of *Carex ternaria* in the bog, the almost complete absence of tussock-grass, and the presence of *Pleurophyllum criniferum*, which, with its very large leaves and striking flowers, must in summer much more emphasize the distinct character of this formation. Certain of the other plants also are much more abundant in the bog than in the meadow, although frequent enough in this latter. These are *Ligusticum antipodum*, *Coprosma repens*, *Coprosma cuneata*, *Stilbocarpa polaris*, *Hymenophyllum multifidum*.

The soil of the bog is peat quite saturated with water, so that water can be readily wrung out of it, and if a small hole be made in the ground it quickly fills with water. Sometimes the centre of the bog may be occupied by a pool of dark peaty water.

Perhaps the most characteristic plant is *Carex ternaria*. At the time of my visit its brown leaves lay prostrate upon the ground, green only at their bases. Here and there *Marchantia* sp. covers the wettest ground, in company with a small moss and a leafy liverwort. Many plants of *Ligusticum antipodum*, either dotted about or in clumps, grow amongst the *Carex*. Such isolated plants have their leaves spreading out radially, and are 40 cm. tall. The surface of the bog consists of little elevations and hollows. In the hollows grow *Luzula crinita* of robust growth, *Marchantia* sp., many lichens, tufts of *Gentiana antipoda*. Considerable patches of ground are frequently occupied by *Hymenophyllum multifidum*, the fronds curled up and of a reddish-brown colour. In other places a dense green carpet of *Coprosma repens* covers the ground, or mixed with it may be lichens and the filmy fern. In most of the bogs *Aspidium vestitum* is present, and occasionally in the driest parts are a few plants of the tussock. Here and there the apices of the leaves of *Pleurophyllum criniferum* just protrude from the ground. *Coprosma cuneata* of very dwarf stature is quite plentiful in some places. It creeps close to the ground, and its small leaves are in winter quite brown. *Uncinia riparia pseudorupestris* is common in some places.

5. *Inland Rocks.*

These I had only an opportunity of examining in two places, so can say little on this head. A sloping rock near the summit of the ridge on its eastern side was covered with a beautiful white-coloured species of *Cladonia*. Through this grew a few small plants of *Coprosma ciliata*(?) about 30 cm. tall, *Lycopodium fastigiatum*, and *Lycopod. varium*, *Hymenophyllum multifidum*, *Helichrysum prostratum*, *Lomaria alpina*, a little stunted *Ligusticum antipodum*, and *Aspidium vestitum*, the whole of these, including the lichen, being also plants of the meadow.

On the face of a dry vertical cliff were white crustaceous lichens, some fruticose lichens, a few mosses, a plant or two of *Colobanthus muscoides*, while on ledges where peat had been formed a tuft or two of the common tussock-grass.

6 *and* 7. *Stream and Swamp.*

For convenience' sake, these two formations are taken together, since I had only an opportunity to examine very rapidly the stream flowing down a gully from the meadow and the swampy ground in its vicinity. The only plant noted in the stream was *Callitriche antarctica*. *Carex appressa* tussock comes to the edge of the water, even extending into it, and filling up the hollow of the gully with great tussocks. Where the ground is a little drier very large grass-tussocks are mixed with the sedge. The ground, so far as I can remember, was very wet, and the tussocks grew much too densely to permit more lowly plants to grow. But my examination was of the very briefest, the allotted time on shore having almost expired. On the map an extensive swamp is marked as existing in the south of the island. Captain J. Bollons tells me he has crossed over this, and that the vegetation consists of large tussocks and of *Aspidium vestitum*, on the top of which you must walk to make any progress and to escape the knee-deep water.

IV. The Bounty Islands.

The Bounty Islands, according to Fairchild, are situated in 47° 43′ south latitude and 179° 05′ east longitude. "The group consists of about twenty islets and rocks ranging from 10 ft. to 290 ft. in height, and occupying a space about three miles east and west and two miles north and south" (90). They lie 490 miles east of the South-west Cape of Stewart Island.

Landing on the main island, where the depot is situated, is a matter of some difficulty; nor is walking on the smooth surface of the granite, of which rock all this group is composed,

by any means easy. This glass-like smoothness is occasioned by the polishing action of the millions of penguins which at present occupy the rocks during the breeding season, and of the fur-seals, which formerly were extremely abundant. These animals, happily, although at one time nearly extinct, are distinctly on the increase, more than sixty being observed during the "Hinemoa's" visit. In summer I understand the rocks are thickly covered everywhere with the excrement of the birds, but at the time of my visit this was nearly all washed away by the abundant rain and sea-spray, which passes at times over the highest island. But in the hollows and under the stones guano was still present, and here Mr. Jennings, of the Otago Museum, and myself had the great pleasure of discovering a peculiar fauna rich in individuals; indeed, in some places the guano beneath the stones was fairly alive with amphipods, beetles, spiders, and small flies, while larger flies were in great numbers on the bare warm rocks.

As for plant-life, the rocks between the ebb and flow are densely covered with the indiarubber-like masses of a species of *Durvillæa* of a much yellower colour than that so frequent in the other islands or on the coast of New Zealand proper. The zone of *Macrocystis*, which so frequently occurs beyond the zone of *Durvillæa* where the plant is not exposed to the danger of buffeting on the rocks, is here absent. On the granite of the island is no permanent soil of any kind except the before-mentioned guano, nor are there any land-plants at all, excepting an alga clothing the rocks and giving them a greenish hue in places. The specimens of this plant which I collected were unfortunately lost, so I cannot state to what genus it may be referred.

Probably these islands are a remnant of a much larger land-area, and the alga not the forerunner of a more extensive future vegetation, but the last survivor of one long passed away. With regard to the spiders, some remarks are made further on when dealing with the history of the vegetation of the Southern Islands.

V. Effect of Animals upon the Vegetation of the Southern Islands.

1. *Indigenous Animals.*

Before the advent of the white man, and even now in many places, vast numbers of sea-birds and seals lived on the Southern Islands for longer or shorter periods every year. The time of my visit was unfavourable for observing the birds, since these for the most part come on land only during the breeding season. I therefore can say little as to how they

affect the plant covering. From the writings of Kirk and Chapman, especially from the latter, something may be learned as to their effect on the vegetation of the Snares. Thus, Kirk writes (56, p. 214), "The island is the abode of numberless penguins, petrels, and other sea-birds, and exhibits numerous indications of their influence on the vegetation." "Two or three swamp-plants exist under difficulties, being constantly flattened under the broad feet of these birds" [penguins], "which abound everywhere." Chapman writes (16, p. 495), "Wherever a rookery is formed the timber or scrub dies, and we often found places where the penguins had taken up new ground, killing a piece of scrub alongside a rookery." The above quotation shows very plainly how great an effect the penguins can have on the plant covering. On the Bounty Islands, where the penguins stand close together in millions, there is no vegetation of any kind, excepting a fresh-water alga which grows upon the rocks. Captain Bollons tells me that they also occupy the cliffs of Antipodes Island in countless numbers, and that small rookeries, where the birds are much scattered, are found at the edge of the forest of the Auckland Group or near the scrub on Campbell Island. The mutton-bird makes holes in the ground, where it rears its young, and such holes must assist very materially in draining the land, while at the same time there will be a good deal of manure on both its surface and in the holes. Chapman describes the whole of the ground of the chief island of the Snares Group as being honeycombed with mutton-bird holes: "The traveller constantly breaks the surface and drops into these tunnels, but the depth is not great." Where the giant petrels (*Ossifraga gigantea*) congregate on Antipodes Island the ground becomes more or less bare, and a quite different association of plants occurs there to what occupies the unmanured slope. As was mentioned in dealing with Antipodes Island, it is here alone that the endemic *Senecio antipoda*, a species differing much from any other New Zealand one, occurs, and I suggested that the rich soil caused by the birds' manure had played an important part in its evolution.*

Various species of albatros breed on the different Southern Islands, and in some parts are extremely numerous. I had an opportunity on both Campbell and Antipodes Islands of seeing the young birds on the nest, and on the latter island was enabled to take some notes as to what plants take possession of the ground which gets laid bare round the nests.

* Moseley shows (79) how a sort of mutual-benefit alliance has sprung up between the penguins and the tussock on Tristan d'Acunha—how the manure benefits the grass and the shelter of the grass the birds. I suspect something of the same with the *Poa foliosa* zone of the Southern Islands.

The nests are built out of peat mixed with short pieces of grass. On Bounty Island, where there is neither soil nor grass, guano and the old quill-feathers of the penguin are made use of. They are quite hard and solid, about 60 cm. in diameter, 25 cm. tall, and the upper surface is very slightly hollowed. On this the albatros lays her one large egg, hatches it out, and the young bird remains on the nest for many months, finally, when fully fledged, walking about just in the neighbourhood of the nest until the following season, when the old bird returns to lay another egg. Then the young bird makes its way to the sea, and first of all takes to the water in this manner. I saw young albatroses both on Antipodes and Campbell Island in July; they were still covered with lovely white down, through which the quill-feathers of the wing were plainly visible when the wind ruffled the down. Round about such nests all the vegetation is finally destroyed for some distance, and it is a most common sight to see old nests surrounded by a ring of quite bare ground, while in other cases a new vegetation has arisen. I took a few notes in order to see what plants under these natural conditions repopulated the ground—as opposed to vegetation being destroyed by introduced animals.

Such old nests may be 39 cm. in diameter and 23 cm. tall, the upper surface, where the young bird has been for many months seated, slightly hollowed. Growing in the centre of the nest is *Stellaria decipiens minor*, with small plants of *Luzula crinita* growing through it. Climbing over the nest and extending into the hollow portion is *Acæna*, which also occupies the formerly bare space round the nest where the old bird has alighted and the young one takes exercise before leaving the nest for the ocean. Large tufts of *Luzula* grow on the ground through the *Acæna*, together with two small plants of *Senecio antipoda*. On the ground, otherwise quite bare, are *Marchantia* sp. and another liverwort. Surrounding the ring of ground laid bare by the albatros are grass-tussock, *Aspidium*, and *Ligusticum*. Another nest examined was bare in its centre, but elsewhere were similar plants to those enumerated and one small plant of tussock-grass. A third bare spot showed rather more tussock. So far as I remember, in all the nests and bare spaces examined *Acæna* and *Stellaria* were the first plants to make their appearance.

The young albatroses also must play a notable part in the distribution of *Acæna*, and may be accountable for the great abundance of this plant all over Antipodes Island. For this idea I am indebted to Chapman's paper, in which, writing of the summit of Mount Galloway, it states, "There was a good deal of flat ground up there which was literally alive with albatroses. Young black birds were very common;

often their breasts were covered with down, and this was matted with piripiri seeds (*Acæna*). The albatroses were building nests everywhere." Such young albatroses, on their way to the water (for they do not fly from the neighbourhood of their nest, but walk to the sea), would certainly assist very materially in spreading the fruits of *Acæna*, or the down coming off with the attached fruit could easily be blown for considerable distances by the furious gales.

The fur-seals will have but little effect on the vegetation although they originally existed in very great numbers, hundreds of thousands having been killed for the sake of their skins. At the present time they are all but extinct in many places, though on the Bounty Islands they are again becoming more numerous, thanks to their being strictly protected by the New Zealand Government. Their rookeries are situated on the more inaccessible rocks at the bases of precipitous cliffs, where they are exposed to the full fury of sea and storm.

The sea-lions play a more important part with regard to the vegetation. These animals frequent the more sheltered stony or sandy beaches. Especially are they fond of the sandy shore of Enderby Island, from which they move on to the sandhills and into the neighbouring meadow or forest. On the sandhills and also on the floor of the forest they roll and wallow about, and as at one time they were present in very great numbers they must have exercised considerable influence in keeping the forest-floor bare, as I have stated when treating above of the *Olearia lyallii* forest. On the sandhills also they would to some small extent loosen the sand, and may have caused sand-drifting, but probably only to a very limited extent.

2. *Introduced Animals.*

In contradistinction to the effect produced by the indigenous animals of any region upon its vegetation, which is, of course, strictly a natural one, to which the vegetation as a whole must have become accustomed, and in response to which the plants in certain cases may have developed special adaptations, the effect of certain introduced animals, including man himself, on the vegetation of a region where such have previously been unknown leads to an artificial state of affairs for a time, which has a most profound bearing on the distribution of the various species making up the vegetation. Excepting man himself, of all animals, where previously none have existed, herbivorous mammals work the greatest change. When in addition to animals foreign plants appear and come into competition with those proper to the region, and, most of all, when man, by the aid of fire in the first place, and afterwards by agriculture and other means, seeks to "reclaim" a virgin waste, then the equilibrium between the plant-forma-

tions is upset altogether, and a new flora and new plant-formations arise. This must have taken place to a greater or lesser extent in all civilised and semi-civilised lands, and their floras and formations must be very different indeed to what they were in the dim past before man appeared upon the scene. At the present time it seems to me that remote regions, especially isolated islands such as those of the New Zealand biological area, are almost the only places where the general laws that govern such vegetation-modifications can be found out, for the gradual changes from purely virgin formations to final "reclamation" can be observed and the factors bringing this about noted. But, so far as the New Zealand biological area is concerned, such investigations must be conducted at once, since year by year the actual virgin formations decrease rapidly in area. Of all places, Campbell Island offers the most favourable conditions for such studies, since all the facts with regard to animals and settlement by man are available, a settlement which has existed for only seven years. In what follows some notes dealing with the matter in hand, kindly furnished by Captain Bollons at my request, have been freely made use of.

(a.) *The Snares.*

These islands have been frequently visited by parties of sealers, who lived there for some months at a time. Beyond cutting down some of the trees and making a few tracks here and there they have had little effect on the vegetation. Where the *Olearia lyallii* trees were felled there is now, according to Kirk (56, p. 215), a dense growth of *Veronica elliptica* mixed with tussock. According to Captain Bollons, goats—perhaps the most destructive of all quadrupeds—were introduced in 1890; but these have most likely died, none having been seen since 1900. The following plants, according to Kirk, are naturalised, but nothing is said as to their frequency or their stations: *Dactylis glomerata*, *Holcus lanatus*, *Poa annua*, *Lolium perenne*. The above and the following New Zealand plants Kirk considers to have been introduced by the sealers: *Sonchus asper*, *Juncus bufonius*, *Hierochloe redolens*, *Deyeuxia forsteri*.

(b.) *The Auckland Islands.*

Captain A. Bristow, in 1807, landed pigs on Auckland Island. Both Hooker and Enderby reported them as very numerous, and Captain Bollons considers that there are still great numbers of them.

During the Ross expedition a ram and two ewes, pigs, poultry, and rabbits were landed on Auckland Island, and seeds of cabbage, turnip, mustard, cress, and other seeds were sown. Gooseberry, currant, raspberry and strawberry plants

were distributed over various parts of the island by Hooker. Rabbits were also landed on Enderby Island. Near the Observatory the forest was set on fire, with the result that the whole country "appeared in a blaze of fire at night" (91, p. 151, *et seq.*).

Enderby introduced cattle and sheep in 1850, but the whole of these were killed by the early sealers. Captain Norman, in 1865, landed four goats, three females and one male, on the south side of Terror Cove, but none of these have been seen since that date.

On Enderby Island cattle, sheep, pigs, and goats were landed by C. Enderby in 1850. In 1865 Captain Norman placed a few goats and rabbits on the island, "which at once took to the English grass" (90). In 1894 cattle and sheep were brought by the "Hinemoa." Probably there are about ten head of cattle at the present time.

Rabbits were put on Rose Island by Enderby, who writes, "I had rabbits in the first instance on a small piece of detached land between Auckland and Rose Island, but they multiplied so rapidly that there was not sufficient food for them," so he removed some of them to Rose Island, where, as on Enderby Island also, there are considerable numbers at the present time. There are also about fifteen head of cattle on Rose Island; some have been placed there in 1894.

Two or three goats were landed on Ewing Island in 1895, but none have been seen recently. On Ocean Island, a very small island in the Auckland Group, goats are numerous at the present time, but I have no details as to how they got there.

On Adams Island Captain Norman landed six Muscovy ducks. Here, also, sheep were landed in 1891, but none have been seen since 1896.

As to the effect of the above-mentioned animals on the vegetation of the Auckland Islands, that of the pigs might be expected to have made its mark. Hooker writes (46, p. 32) of *Pleurophyllum criniferum* "forming the larger proportion of the food of the hogs which now run wild upon the islands of Lord Auckland's Group. It is, indeed, so abundant in the marshy spots on these latter islands that these animals frequently live entirely amongst it, especially when it grows near the margins of woods, where they form broad tracks or runs through the patches, grubbing up the roots to a great extent, and by trampling down the soft stems and leaves use them as warm and soft forms to litter in." According to Mr. McCormick, who was surgeon on the "Erebus," the pigs fed on *Stilbocarpa polaris*. The rabbits also, confined to two small islands, must have destroyed a considerable amount of vegetation, and have changed to some extent the percentage of the smaller grasses and other herbaceous plants on which

they may feed. As for the cattle, Captain Bollons considers that they have already brought about considerable changes in the swampy ground of Enderby Island by consolidating it; and in dealing with the sand-dunes I have shown how these animals have already changed stable into unstable dunes, in which work the rabbits also may play some part.

At the time of the Enderby Settlement, as before pointed out, a considerable piece of the forest in the north of Auckland Island was cleared. This cleared ground is now completely reoccupied by a new formation differing in some important characters from the original rata forest. This new formation consists of a dense growth of evergreen shrubs, and with these is mixed a considerable percentage of *Phormium tenax*. This latter plant is not indigenous to the group,* it having been introduced by the sealers, who made use of the leaves for making sandals in which to chase the fur-seals over the extremely slippery rocks. That *Phormium tenax*, a most characteristic New Zealand plant, should be on the increase, and more than holding its own with the secondary arborescent growth, is a matter of interest distinctly bearing on the question of former land-connection with New Zealand proper; but it must be borne in mind that such secondary growth as that under consideration is the result of changes brought about by man, and the spread of *Phormium* under such circumstances is no proof that it would increase if introduced into a primitive formation. The new formation consists of *Metrosideros lucida*, *Panax simplex*, *Coprosma fœtidissima*, *Dracophyllum longifolium*, and *Phormium tenax*, the whole forming a most beautiful natural shrubbery of various hues of green. Unfortunately, there was no time to examine the undergrowth, or to take notes as to the relative quantity of the various components.

Regarding the introduced plants of the Auckland Group I can say but little. So far as I could judge at a season most unfavourable for such investigations, the vegetation of the flat ground between the sand-dunes and the forest on Enderby Island is largely modified, and contains a number of introduced grasses and other plants growing mixed with some of the more lowly indigenous herbs. It would be in this locality that the goats and rabbits which took so kindly to the English grass were landed in 1865 by Captain Norman. During this last-named expedition certain exotic plants were planted in various localities. Thus, oak, ash, and pine trees

* Mr. W. Joss tells me that he remembers when there were only three plants of *P. tenax* in this locality. On the occasion of our visit he landed at this spot purposely to gather some *Phormium* leaves, remembering well that the plants were there, although he had not been to the group for many years.

were planted, and seeds of lettuce, turnip, carrot, parsnip, pumpkin, and other vegetables were sown, on the south side of Terror Cove, while on Adams Island several young trees were planted and seed sown at the head of Carnley Harbour (90). *Phormium tenax*, as I have pointed out above, is an introduced plant, and it is distinctly on the increase; if it finally spreads on to the wet open ground it may considerably modify the *Pleurophyllum* formation. It should also be able to thrive on the sand-dunes, and everywhere, indeed, except in the subalpine region. Finally, I may add that the question of the effect of introduced animals, &c., on the vegetation of the Auckland Group, owing to the many animals that have roamed there for some time, and the length of time that introduced plants have had a footing in some part or other of the group, is a matter of considerable complexity, and cannot be grappled with except by a long residence in the group. Generally speaking, however, I think it safe to conclude that almost all the forest and scrub formations and by far the largest part of the remainder are, to all intents and purposes, in their virgin condition.

(c.) *Antipodes Island.*

Here the conditions are very much more simple than in the Auckland Islands, for it was not until the year 1887 that any exotic animals were introduced. Since then, and up to the last visit of the "Hinemoa," in July, 1903, cattle, sheep, and goats have been landed on several occasions, but such invariably died after three or four years. At the present time there are on the island only the three heifers which were landed in July last. It is very easy to see how such tussock slopes and swamps as those I have described are most unfavourable for the well-being of domestic animals. Sheep, thickly clothed with wool through not being shorn, if they once fall down in such tussock meadows can never rise again, and must perish. Cattle certainly may get on better, and might make tracks through the tussocks; but whether they could thrive exposed to the furious gales in the more open lands of the interior is questionable. It seems highly probable that the peculiar vegetation, aided by the climate, might quite well prove the victor in the struggle with any introduced domestic animals left uncared-for on the island. Were the place to be turned into a sheep-run, where the sheep were annually shorn and the tussock burnt off, then, indeed, the face of nature might be changed, and one of the most wonderful natural museums in the world be destroyed, which would, indeed, be a scientific calamity in no wise to be compensated by the trivial and problematical gain that could be acquired by sheep-farming on Antipodes Island.

(d.) *Campbell Island.*

Here sheep-farming is an accomplished fact. My notes, in consequence, afford some clue as to the effect that sheep and fires have on an absolutely virgin vegetation, which has existed for ages without having been exposed to either of these factors. Unfortunately, I was unable to make any list of the introduced plants; but the presence of these hardly affects my results, since there are few, if any, introduced plants at the higher levels where my notes were taken. At the time of the visit of Captain Norman six oaks, six elms, and one ash-tree were planted. Three pigs, some game and guinea fowls were at the same time landed at the head of Perseverance Harbour. The pigs and, I presume, none of the other animals have been seen there for the past twenty years. In 1890, according to Captain Bollons, sheep and goats were landed; the sheep died off, but probably two or three goats remain. In 1896 the sheep-farming was commenced. Only a few sheep were brought at first, but these have been frequently added to; they have also increased by natural means, and now there are about 4,500 on the island. Burning has also been largely resorted to in order to get rid of the scrub and make travelling more easy both for the sheep and the shepherds.

Now, it is obvious that at first the sheep would be confined to comparatively small areas, and that a small number would affect the vegetation to an equal degree as quite a large number would if these latter were equally distributed over the whole island. Even now the 4,500 sheep do not roam over more than half the surface of the island, and still less than that if we take into account the scrub, gullies filled with scrub, patches without new vegetation where burning or overstocking has taken place, *débris*-slopes, and rocks. Consequently the sheep exert almost a maximum influence upon the plant-formations. There are certain plants of which the sheep are especially fond. These are *Danthonia bromoides*, *Pleurophyllum speciosum*, *Ligusticum latifolium*, and *Stilbocarpa polaris*. *Pleurophyllum hookeri* is eaten to some extent; and so, of course, are the various small grasses and the "silver-tussock." *Celmisia verincosa*, *Cel. chapmanni*, and *Bulbinella rossii* are not touched.*

The lower tussock meadow formerly contained vast quantities of *Pleurophyllum speciosum*. This the sheep devour most greedily, eating right down into the plant almost to the root-stock. On the slopes of Mount Honey were hundreds of plants, the leaf-rosettes eaten quite away, the remains of the dead plant looking not unlike the nest of a bird. In some

* From information supplied by Mr. J. Gordon.

instances, perhaps, such plants are not killed outright, and may recover. In course of time in all the formations where sheep can feed this magnificent plant will be destroyed, and, so far as Campbell Island is concerned, it will only be found in rocky hollows of the cliffs where a sufficient amount of peat can accumulate.

It is the subalpine tussock meadow and the tussock scrub that are undergoing the greatest changes. In the former, as pointed out before, the noble grass *Danthonia bromoides* forms great tussocks as large as the largest snow-grass tussocks of the Canterbury mountains. These are eaten right down to their base in one year, if the meadow is heavily stocked, and nothing remains but great roundish decayed mounds, the bases of the leaves projecting upwards, the whole 30 cm. or more in height. Such heaps, at a distance of 90 cm. or so apart, meet the eye all over the hillside. Between these dead tussocks on the south side of Lyall's Pyramid occur the following plants: *Phyllachne clavigera*, various species of lichens, *Luzula crinita*, *Coprosma repens*, a few young grasses belonging to species I could not identify at the time, *Hymenophyllum multifidum*, *Pleurophyllum speciosum* (this mostly quite killed), *Pleurophyllum hookeri* (a good deal eaten), *Epilobium confertifolium*, *Bulbinella rossii* (in large quantity). On the dead rotten hummocks of *Danthonia*, *Phyllachne*, some mosses, and *Coprosma repens* were growing, and on the ground near by *Stellaria decipiens* had become very abundant. *Here, then, a distinctly changed formation is in process of evolution in which the two most striking plants, which stamp the physiognomy of the original formation, will be altogether absent, while some of the smaller plants, kept in check by these dominant larger ones, will increase considerably in numbers.* The next phase in the history of the changed formation will be when introduced plants put in an appearance and contend with the present survivors for possession of the ground, and it is certain from New Zealand experience that many of these will be equally or better in harmony with their new surroundings than are the endemic species.

In some parts of the subalpine region the new formation is somewhat different from that just described, in so much that very large quantities of a small indigenous grass are occupying the ground. According to Mr. Gordon, the manager of the Campbell Island sheep-run, this grass is not destroyed by the sheep, although they feed upon it. If this is so, another meadow formation is in process of evolution, depending probably upon the amount of moisture in the soil. This grass was especially noticeable on the ground below the cliffs on the north side of Lyall's Pyramid.

In certain places the "tussock scrub" has been burned,

and, of course, sheep also can range, and have most probably ranged, over it. Such spots are specially instructive, because these burnt and unburnt portions of the formation can be observed side by side. An account has been given, when dealing with Campbell Island, of this virgin formation, so no more need be said on this head. The burning would, in the first instance, destroy all the plants and parts of plants which were above the surface of the ground. Some would be killed outright, and others spring up again from their underground parts. At the time of my visit the former tussocks were indicated by rotten dead masses of leaves, &c. The *Coprosma* bushes were a mass of dead interlacing branches, which showed most admirably the manner of growth of those shrubs. The floor of the formation beneath such dense bushes had formerly been quite bare, there being neither space nor light enough for plant-life. Now the floor beneath such *Coprosma* skeletons is most densely covered with the pale bluish-green *Acæna;* but frequently this is mixed with *Epilobium linnæoides* and *Stellaria decipiens*. Such new growth is usually of extreme closeness. In the new formation *Aspidium vestitum* is abundant, having come up again from its rootstock after being burnt to the ground. On the ground between the *Coprosma* skeletons and the *Aspidium* is much *Acæna*, while *Epilobium linnæoides* and *Stellaria decipiens* are exceedingly abundant. *In this case, again, the plants which give the stamp to the physiognomy of the original formation are no longer present, while certain plants present in no great abundance before, and which have come up from seed, are now dominant*, the *Acæna* especially being on the point of becoming a "weed" in the eyes of the farmer. This changing of indigenous plants into weeds by disturbing the balance of nature is well shown in Chatham Island, where, even in ground constantly grazed by sheep, *Acæna novæ-zealandiæ* is extremely abundant (23, p. 306), while the frequent burning of bog-vegetation has finally led to the common bracken—*Pteris esculenta*—occupying large areas where formerly it hardly existed, and hindering the growth of grasses available for stock (23, p. 307).

Where the *Dracophyllum* scrub of the lower levels has been burned *Acæna* also is making great headway, though here also *Aspidium vestitum* remains. Most probably such burning of scrub will in time transform the whole scrub formation of the island, except in deep gullies, into meadow of some kind or other.

From the above it is very easy to see that Campbell Island will be a very different place in a few years' time, so far as its plant-formations and plant inhabitants are concerned, if the island continues to be a sheep-run. Possibly none of these latter will be altogether destroyed, unless it be *Danthonia*

bromoides, but some of the most common meadow-plants will be found only on rocky crevices or in the bottoms of unburnt gullies, while other plants formerly kept in check by the vegetation-conditions of the island will have increased to a remarkable extent, some actually becoming "weeds," unless their spread is again checked by some foreign species which may get into the flora. At any rate, after a time equilibrium will be once more restored, and formations apparently natural come into being in harmony with the new biotic surroundings. *Under such a condition of affairs some of the then rarest plants will have formerly been the most common, and some of the commonest have been comparatively rare, and have been confined originally to quite different stations.* Thus, originally common meadow-plants may be only rare and local on rocks, and small rare and local rock-grasses may be the chief meadow-grasses. Such facts as these seem to me to have a distinct bearing on plant-distribution in the civilised countries of the Old World.

VI. History of the Flora of the Southern Islands.

To deal at all exhaustively with the history of the flora of the Southern Islands would necessitate going into the origin of the whole New Zealand flora, an undertaking altogether too great for a paper such as this. All that can be attempted here is to give some details regarding the elements of which the flora is composed, and to make some remarks as to its possible origin, specially referring to any matter contained in what has gone before that sheds light on this subject.

The elements of the flora are three—an endemic, a Fuegian, and a New Zealand, this latter itself a complex, but here treated as a single element. Only the spermaphytes are here considered. The presence of pteridophytes easily spread by wind is of no very great importance in any discussion regarding the presence of identical forms on land-areas separated by wide stretches of ocean.

The total number of spermaphytes, counting both species and well-marked varieties, is 138, of which 54, or 39 per cent., are endemic; 26, or 18·8 per cent., Fuegian; 7, or 5 per cent., Fuegian which do not extend to New Zealand; and 58, or 43·1 per cent., New Zealand, excluding the New Zealand – Fuegian element, consisting of 19 species. After some hesitation I have included two species which extend to the Chatham Islands amongst the endemic plants.

If we now consider the endemic element, it may be divided into two classes—viz., those species found in only one island of the group and those occurring on more than one. Of the former there are 25 species, which are thus distributed: Auckland Islands, 10; Campbell Island, 7; Antipodes Is-

lands, 3; Macquarie Island, 3; Snares Islands, 2. Regarding the 29 species found on more than one island, 1 (*Colobanthus muscoides*) is found on all the islands; 2 (*Luzula crinita* and *Stilbocarpa polaris*) occur on Auckland, Campbell, Antipodes, and Macquarie; 2 on Auckland, Campbell, and Macquarie (*Pleurophyllum hookeri* and *Stellaria decipiens*); 1 on Auckland and Antipodes (*Pratia arenaria*—also very common in Chatham Island) (23, p. 305); 1 on Snares and Auckland (*Olearia lyallii*); 1 on Auckland and Chatham (*Poa chathamica**); 6 on Auckland, Campbell, and Antipodes (*Acæna sanguisorbæ antarctica, Epilobium confertifolium, Ligusticum antipodum, Pleurophyllum criniferum, Coprosma ciliata, Poa* sp.—the common tussock-grass forming large "trunks"); and 15 on Auckland and Campbell Islands. This distribution of the endemic species shows Auckland and Campbell Islands to be the headquarters of the flora, which, on account of the size of the former and of the number of plant-stations provided by the configuration of the latter, might be expected.

The endemic species are in many cases very closely related to New Zealand ones; indeed, regarding some of them it is a question whether they are not either identical with or at best forms of existing New Zealand species, as, *e.g.*, *Epilobium confertifolium, Pratia arenaria, Azorella reniformis, Coprosma ciliata, Plantago* sp. (the *P. brownii*(?) of the Aucklands), *Ranunculus subscaposus, Aralia lyallii robusta, Acæna sanguisorbæ antarctica, Astelia linearis subulata, Cardamine depressa stellata*, &c. But, notwithstanding this, the endemic element is very clearly defined through the presence of two endemic genera—*Pleurophyllum* and *Stilbocarpa*—and such species as *Ligusticum latifolium, Lig. antipodum, Celmisia vernicosa, Cel. chapmanni, Senecio antipoda, Veronica benthami, Colobanthus muscoides, Cotula lanata*, and *Bulbinella rossii*.

If we turn now to the 58 New Zealand species, 51 are endemic and the remaining 7 Australian. A summary of the stations in which they and the New Zealand – Fuegian species are found in New Zealand proper is not without interest. For this purpose I have roughly classed these stations under three heads—coastal, forest, alpine and subalpine. Under the term "forest" is included not only the plants of the forest proper, but those which are found in

* It is doubtful whether this grass occurs in Auckland or Antipodes. Moreover, Petrie, who recorded its occurrence in the Southern Islands, shows that it differs from the Chatham Island plant in certain particulars; but he adds (85, p. 395), "It is clearly a form of the present species" [*P. chathamica*], "and presents only such subvarietal differences as might be expected from the difference of habitat combined with long isolation."

the forest region, even if meadow-plants. This classification is quite a rough one, for many plants are found in all kinds of stations and at all kinds of altitudes. Placing the New Zealand species after (*a*) and the New Zealand - Fuegian after (*b*), the figures are: Coastal — (*a*) 12, (*b*) 8 = 20; forest — (*a*) 18, (*b*) 2 = 20; alpine and subalpine — (*a*) 28, (*b*) 9 = 37. Thus, the mountain-plants are considerably in excess of either of the other classes; and this is more accentuated when it is pointed out that the forest - plants are in large measure plants of a forest which ascends to the lower subalpine region, or is found usually, when at a lower altitude, under such conditions as will permit the growth of alpine plants at a low level—*e.g.*, Stewart Island, west coast of South Island, &c. Generally speaking, these alpine plants are not amongst those most characteristic of subalpine and alpine plant-formations. Certain genera, such as *Raoulia*, *Gaultheria*, *Euphrasia*, *Ourisia*, *Pimelea*, *Forstera*, *Gunnera*, *Wahlenbergia*, and *Coriaria*, are altogether wanting; and of the numerous species of *Celmisia*, *Olearia*, *Veronica*, and *Senecio* none of the mountain forms extend to the Southern Islands, where, however, they are represented by one or two Southern Islands' endemic or New Zealand coastal species. Of the more common mountain-plants common to New Zealand and the Southern Islands, it is an interesting fact that they are frequently plants of New Zealand alpine bogs, in certain places, however, in the south of the South Island and in Stewart Island occurring also in bogs at sea-level. Amongst these are *Gaimardia ciliata* and *Gaim. pallida*, *Drosera stenopetala*, *Oreobolus pumilio*, *Scirpus aucklandicus*, *Cyathodes empetrifolia*, *Ehrharta thomsoni*, *Carex ternaria* (also frequent in lowland stations), and *Juncus scheuzerioides* (see also Diels, 27, pp. 254, 257). Some of the alpine plants belong to the subalpine scrub—*e.g.*, *Coprosma cuneata*, *Dracophyllum longifoliun*, *Drac. urvilleanum*,* *Myrsine divaricata*, *Cassinia vauvilliersii*. *Coprosma repens* is a very common subalpine meadow-plant, while *Helichrysum prostratum* is by no means widespread, but its close ally *H. bellidioides* is everywhere on the mountains.

Having now briefly considered the elements of the flora, we are led to inquire how did they reach a number of very small islands not merely far away from any centre of distribution, but distant from one another some hundreds of miles; and, above all, how comes it that this group of islands has nearly 19 per cent. of its flora composed of species—twenty-six in number—which occur in the southern part of

* This is if we accept Kirk's identification of the species of *Dracophyllum* most common in the scrub of Campbell Island.

South America, distant about half the circumference of the globe? Two explanations have been suggested: one that seeds of these Fuegian plants were brought by winds, by birds, by ocean currents, on icebergs, &c.; the other that changes more or less great in the configuration of the lands of the Southern Hemisphere have taken place, bringing different points either into direct land-communication or very much nearer than they are at present. Correlated with this latter view is the belief that a milder climate may have existed in the Southern Hemisphere than is now the case.*

As to the first hypothesis, I may point out that introduced land-birds have been blown from New Zealand to Auckland Island and to Chatham Island, and that in consequence certain European birds are now naturalised on these two islands. The smoke of bush-fires reaches Chatham Island during certain winds from New Zealand. Dr. P. Marshall has recently shown (76) how a storm of dust has reached New Zealand from Australia, and how during such an occurrence small seeds could reach New Zealand from Australia. Certain islands are supposed to have been colonised with plants entirely by such methods as the above, the Azores and Bermudas being cases in point. As for the latter group, Trelease considers(101*a*) that most of the existing species have been introduced largely by human agency since the discovery of the islands.

As for the currents, Captain Bollons writes to me: "The current, generally speaking, is a set to the eastward, sometimes at the rate of one and a half knots per hour. Have not noticed anything in the shape of driftwood or flotsam of any kind which could be taken as coming from other lands." So far as Chatham Island is concerned, logs from New Zealand have been frequently cast up on its shores.

Sea-birds, as shown previously, are enormously abundant on these islands. Some of these make their nests in the ground, and so, as Moseley has shown, may get their feathers covered with vegetable mould, which in some cases will contain seeds. The fruits of *Acæna*, as shown above, adhere in large numbers to the feathers of the albatros. Whether such sea-birds visit any other islands than the one on which they breed I do not think is known; nor are any facts available as to how much exposure to salt-water the seeds of the plants under consideration could tolerate. As to whether sea-birds will eat the fruits of berry-bearing plants, for instance, there is, so far as I know, only the testimony of Dr. Guppy (37), which refers merely to one case.

* This is now confirmed by Mr. Ferrar's splendid discovery of fossil plants on the Antarctic Continent during the recent British Antarctic Expedition.

Generally speaking, the consensus of opinion amongst botanists is against seeds being brought in appreciable quantities over wide stretches of ocean, and I do not think that any one at the present time claims that all the ancestors of the New Zealand flora arrived in this manner.

As to whether the Southern Islands got their New Zealand element by wind-carriage, water-carriage, bird-carriage, &c., I will only make one or two remarks. The seeds of New Zealand plants as a whole do not germinate very readily; nor will the majority germinate at all unless the conditions be very favourable. Seeds of introduced plants in New Zealand, even those of most aggressive species, rarely produce plants that come to maturity in undisturbed ground in mountain regions where introduced animals, including man, have never been. Even on the lowlands it is the ground that has been disturbed that they seize upon, and it is under artificial conditions that they exterminate indigenous plants. Plants from a flower-garden, even when they seed freely and produce young plants in the garden itself, rarely invade the surrounding country by means of seedlings. So far as I have observed, it is only plants with certain special adaptations which become naturalised in special positions and there become dominant.

The presence in the Auckland Islands of a New Zealand rata forest—*i.e.*, not of a number of separated species, but of a distinct plant-formation such as one might encounter in many parts of the South Island—is a matter bearing directly upon the question of former land-connection between the southern parts of the New Zealand biological area. This rata forest, wanting some few of its usual constituents, indeed, but otherwise, excepting for its peculiar physiognomy, which is in harmony with the climatic conditions, is a true New Zealand rata forest, a combination of *Metrosideros lucida*, *Panax simplex*, *Dracophyllum longifolium*, *Coprosma fœtidissima*, *Suttonia divaricata*, beneath the shade of which are the ferns, mosses, liverworts, and lichens which one would expect to be there. Were the tree *Weinmannai racemosa* present nothing would be wanting. The presence of such a forest some hundreds of miles from New Zealand is to me a most striking fact. It is quite conceivable how seeds or fruits of many plants might be brought by wind, by birds, or other agencies, but that such should consist in large measure of the plants of some special formation, and that they should arrange themselves in almost exactly the same manner as they did in the land of their nativity, is a matter much more difficult to believe than that New Zealand has extended to the south far beyond its present limits, and that on such land a previously existing forest has slowly moved southwards. This brings us at once to the question of what evidence there

is regarding former extension of New Zealand, and while on this topic the question of former antarctic land-areas occupied by plants may be briefly discussed. To approach this difficult question we must turn to the geological history of New Zealand. Captain Hutton's most recent utterance on the subject may be taken as summing up what is believed to be known on this head Here there is no need to go into Hutton's arguments; only some of his conclusions need be stated: "In the middle of the Jurassic period came a violent upheaval." "The new land, which we may now call New Zealand, for it has never since been entirely covered by the sea, extended in a westerly direction to at least twice its present breadth, and to the north it joined New Caledonia and New Guinea, which at that time probably formed part of a South Pacific continent.* Plants and animals—including snails, worms, and insects, but no birds—came trooping down from the north to form the basis of our flora and fauna." "In the Upper Cretaceous the land subsided, and New Zealand was reduced to comparatively small limits." "A little before the commencement of the Tertiary era the rocks were folded once more, the land rose again, and again it stretched far away to the north, but was not again united to New Guinea or to northern Australia. A second invasion from the north followed, and quantities of plants of all descriptions, accompanied by animals—among which were many land-birds—migrated to New Zealand, and it is the descendants of this Eocene invasion which form the greater part of the present fauna and flora." "In the older Pliocene came the last great upheaval. All the islands were joined together, and the land stretched away to the east and south so as to include the Chatham and Auckland Islands, as well, perhaps, as Campbell and Macquarie Islands, while to the north it certainly extended to the Kermadecs and much further. Probably at this time more land existed in the Antarctic Ocean, for New Zealand added to its flora and fauna many antarctic plants and marine animals. But this land could not have connected New Zealand with either Patagonia or South Africa, for if it had done so we should certainly have had more immigrants, including land-birds and probably mammals" (52, pp. 181, 182).

Wallace, although far from agreeing with Hutton in all his conclusions. also believes in a much greater extension of New Zealand, and seeks to show how the basis of its flora came from Australia (102, p. 506) during a period—probably

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* The recent discovery of species of *Corynocarpus*, supposed to be endemic in New Zealand, in New Caledonia and New Hebrides is of great interest in this connection (43*a*).

the early Tertiary—when that continent, although connected with New Zealand, was itself divided into an eastern and a western half by a wide strait (102, p. 496), New Zealand having previously possessed "a scanty vegetation of mixed antarctic and Polynesian origin" (*l.c.*, p. 499). By the above means New Zealand would get the thirty-two tropical genera common to it and Australia, and probably "thirty-two more genera, which, though chiefly developed in temperate Australia, extend into the tropical or subtropical portions of it, and may well have reached New Zealand by the same route" (*l.c.*, p. 501). The ninety-six species common to New Zealand and Australia at a much more recent period in some manner or other crossed the sea, at least six hundred miles broad, between New Zealand and Australia. The Fuegian plants, many of which belong to northern genera, the New Zealand genera *Pachycladon* and *Notothlaspi*, "said to have affinities with arctic plants," and *Stilbocarpa*, with its "nearest allies in the Himalayan and Chinese *Aralias*" (*l.c.*, p. 519), came from South America (the arctic and northern elements by way of the Andes during the glacial periods), some settling down in Tierra del Fuego and Southern Chile; others passed over the five hundred miles to the South Shetlands, and thence by way of the antarctic continent or group of large islands to Adélie Land, and thence to Young Island. From here they travelled across the sea 750 miles to Macquarie Island, and thence across another expanse of sea to New Zealand or Tasmania, these lands at this time having a considerable extension to the south.

Dr. H. O. Forbes advocates actual land-connection between the New Zealand biological area, the antarctic continent, South America, South Africa, &c., but unfortunately only the short notice of his views in *Nature* and certain letters he wrote in that journal are available here (36).

With regard to direct land-connection between New Zealand and South America, the presence of genera of animals which could not tolerate sea travel is of the highest importance. Such, for instance, are earthworms. Regarding the genus *Microscolex*, of which a species, *M. huttoni*, occurring in Chatham Island, was recently described by Dr. W. B. Benham, that author writes (6, p. 143), "The existence of this genus here in New Zealand, with four distinct species, goes very far towards supporting a land-connection with South America, and points perhaps rather to a connection with the northern part of the southern continent than with the extreme south." Another worm is *Acanthodrilus macquariensis*, Benham, of Macquarie Island, which "has closer affinities with the species occurring in Patagonia, the Island of South Georgia, and the Falkland Isles than with those of New Zealand" (*l.c.*, p. 132);

while as for *Notiodrilus aucklandicus*, Benham, of the Auckland Islands (7) the same may be said, it in addition having affinities with South African species.*

Spiders, again, are animals which could not travel by means of the sea or be blown for long distances by wind. On the Bounty Islands, which consist entirely of granite, and therefore are of great age, as pointed out before, are many spiders. Specimens of these, collected by me in July last, were sent to Mr. H. R. Hogg, who thus writes regarding them to Professor C. Chilton, to whom I gave the specimens, "The spiders you sent from Bounty Island are most interesting. Their nearest congeners are from the south of South America, and although they are typical of a well-defined family, the *Cybocinæ*, I have had to make a new genus for them." "They would seem to add another link to the connection of South America with Australia."

Dr. H. Woodward, in a recent paper, sums up the evidence, geological, zoological, and botanical, in favour of a former antarctic continent containing an abundant fauna and flora, and concludes that "a summary of the flora characteristic of the Southern Hemisphere fully confirms the conclusions derived from a study of the fauna, and establishes beyond a doubt the former existence of extensive land-connections between the southern continents and islands in Tertiary times which have since disappeared beneath the ocean" (105, p. 429).

Now, all the above does not put us much beyond Hooker's classical theory of a much greater extent of land in the Southern Hemisphere to account for that most wonderful fact, the exact similarity of the flora of all the antarctic islands from Cape Horn to Kerguelen Land, a similarity so great that Alboff includes in his term "Fuegian flora" the plants of all the land on the western side of the Andes from and including the Chronos Archipelago and the numerous isles along the coast, the greater part of the north side of the Strait of Magellan, Tierra del Fuego (excepting its northern flat portion), the Falklands, and the other islands at about the same latitude up to and including Kerguelen Land (1).

I have pointed out above how the presence of the rata forest in the Auckland Islands supports Hutton's theory of a great southern extension of land during the Pliocene period. On the other hand, the *Pleurophyllum* meadow may be the last remnant of a former much more extensive southern meadow formation. *Pleurophyllum*, an endemic genus in the

* During my excursion I collected a number of earthworms, of which probably one from Antipodes and two species from Campbell Island may be of some interest. These are now in Professor W. B. Benham's hands for identification.

Southern Islands, and occurring in the whole of them except the Snares, is, according to Bentham (4*a*, p. 407), closely related to the Andine section *Orithropium* of Erigeron, as is also *Celmisia*. If, with Bentham and the "Pflanzen-Familien," we consider all the southern species of *Ligusticum* to belong to *Aciphylla*, then this may also be, perhaps, called an "antarctic genus," although most closely related to the northern *Ligusticum*. *Acæna*, *Epilobium*, *Uncinia*, and *Veronica* may also well have belonged to this problematical ancient plant-formation. The presence of *Stilbocarpa* and *Bulbinella* present more difficulties. The former, as stated above, is allied to the Chinese araliads, so it either did not belong to the above suggested ancient antarctic plant-formation, or its ancestors in other parts of the Fuegian region have long since died out, these coming, as Wallace suggests, from the north during the glacial period. As for the presence of the South African genus *Bulbinella*, it is one of those remarkable South African relationships such as *Peripatus* amongst animals.

The bright colours of the flowers of this formation—blue, red, purple—have already been alluded to. Captain Hutton has shown that such in this case is hardly correlated with the visits of insects (53*b*). It seems to me most probable that these colours originated through the greater amount of sunlight to which the plants would be exposed during the long summer days of a higher latitude.* On this head Schimper writes (92, p. 716), "Die in den meisten Reiseberichte erwähnte Farben-intensität der arctischen Blüthen wird gewöhnlich und wohl mit Recht, als ein Wirkung der andauernden Beleuchtung aufgefasst."

On the Snares, Ewing Island, and in one or two places on Auckland Island is an *Olearia lyallii* forest. This is apparently just as much in harmony with its surroundings as is the dominant rata forest; but I think there can be little doubt, from what has been said in treating of the forest-formations of the Auckland Islands, that this *Olearia* forest was once more extensive, but has been gradually driven into smaller and smaller compass by the encroaching rata forest. In my opinion, the *O. lyallii*† forest is the ancient forest of the Southern Islands, perhaps, indeed, that of a part of the problematical antarctic continent; but it could not withstand the more vigorous Pliocene invader. The genus *Olearia* is exceedingly common in New Zealand, there being at least thirty-four species. According to Bentham (4*a*, p. 405),

* On the other hand, their luxuriant growth does not point to evolution in a rigorous climate.

† According to this view *O. lyallii* and many of the endemic plants are examples of "relict endemism," and not of "initial endemism," to use the term suggested by Shull (94).

Olearia is closely allied to "the antarctic or subantarctic genus *Chilotrichium*, a genus of three species, one of the numerous connecting-links between the Australian and extra-tropical or Andine South American floras. This genus is closely allied as well to *Olearia* of the former as to *Diplostephium* of the latter region." *Olearia lyallii* belongs to a distinct division of the genus confined to the New Zealand area, distinguished by their large solitary heads, usually solitary on terminal peduncles, but in one species with simple 3–8-flowered racemes. Kirk has called this section of the genus the macrocephalous *Olearias*. Besides the flower-heads, the foliage is very distinct. With one exception, the xerophytic *O. insignis*, they all occur in the very wettest regions of the South Island or on the Chatham Islands, Stewart Island, and the Southern Islands. *O. lyallii* is very closely allied to *O. colensoi* of Stewart Island and the western subalpine scrub in the South Island.

The extraordinary plasticity of many New Zealand plants, shown by the great changes in leaf-form which can be quickly brought about by culture under conditions different to what they experience in nature, and the striking heterophylly exhibited in a state of nature by a great number of plants, points distinctly to the species being by no means in harmony with their present surroundings. *Discaria toumatou* cultivated in moist air no longer produces spines, but in their place are drooping leafy shoots. Many species belonging to the genera *Raoulia*, *Veronica*, and *Carmichaelia*, all most characteristic New Zealand genera, will revert to the seedling form by cultivation in moist air or feeble light (see Pl. XXII.), or under the same conditions the seedlings in some cases will never assume the adult form. The case of New Zealand xerophytic shrubs as affording evidence of the Pliocene land-extension has already been cited.

As for further evidence regarding land-connection with South America, no more need be said except to point out the great resemblance between the flora of Kerguelen Land and that of Macquarie Island. In this latter island no fewer than nine out of twenty-seven species are Fuegian, and if we omit the endemic species of Kerguelen Land, including *Poa cookii* as such, six out of the remaining fifteen species occur on Macquarie Island, amongst which is the wonderful *Azorella selago*, which does not extend to any of the other islands.

Whether all the Southern Islands have formed a part of New Zealand during its one, or it may be more, southern extensions is a debatable point. Filhol (35*a*), from geological evidence collected on the island during a stay of a considerable period, claims that Campbell Island has always remained isolated. Hector, on the contrary, considers that

some part has been above sea-level since before the volcanic outburst to which almost all the present island is due. So far as the botanical evidence is concerned, the many species these islands have in common points distinctly to connection.

As for Antipodes Island, Hutton suggests that this has never been united to the other Southern Islands. Here, again, I think the botanical evidence is in favour of land-connection, for the prevailing north-west wind would be just as likely to colonise it with plants from New Zealand as the south-west with plants from others of the Southern Islands.

The Bounty Islands are perhaps the last remnant of a portion of greater New Zealand, and its scanty algal flora not the commencement of a land flora on a new-born land just issuing from the waters, but the last survivors of such a vegetation as that which has been described for these Southern Islands.

VII. List of the Indigenous Spermaphytes and Pteridophytes of the Southern Islands.

In the following the various elements which make up the flora of the Southern Islands are thus indicated: A = endemic in the Southern Islands; B = occurring also in New Zealand; C = Fuegian, using this term in the wide sense proposed by Alboff (1).

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
Ranunculaceæ.					
Ranunculus pinguis, Hook. f. A	..	1	1	..	..
R. acaulis, Banks and Sol. B	..	1	..	..	..
R. subscaposus, Hook. f. A	..	..	1	..	..
R. aucklandicus, A. Gray. A	..	1	1?	..	..
For the Campbell Island habitat see Kirk (57, p. 387). Probably he confused *R. subscaposus* with this species, for he only gives Auckland Island as habitat in "Students' Flora."					
R. hectori, Kirk. A	..	1	..	..	..
I am by no means sure that this is distinct from *R. aucklandicus*.					
R. crassipes, Hook. f. C	..	..	..	..	1
Cruciferæ.					
Cardamine hirsuta, L., var. *subcarnosa*. B	..	1	1	..	1
C. corymbosa, Hook. f. B	..	1	1	..	1
C. depressa, Hook. f. B	..	1	1	..	..
C. depressa var. *stellata*. A	..	1	1	..	..
Lepidium oleraceum, Forst. B	1	1	..	..	..
For Auckland Island habitat see Kirk (59, p. 379)					

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie
CARYOPHYLLACEÆ.					
Stellaria decipiens, Hook. f. A	..	1	1	..	1
S. decipiens var. *angustata*, T. Kirk. A	..	..	..	1	..
Colobanthus billardieri, Fenzl. B, C	..	1	1	1	1
C. subulatus, Hook. f. B, C	..	..	1	..	..
C. muscoides, Hook. f. A..	1	1	1	1	1
PORTULACEÆ.					
Montia fontana, L. B, C..	..	1	1	..	1
Occurs in north and south temperate regions.					
GERANIACEÆ.					
Geranium microphyllum, Hook. f. B	..	1	1	..	..
Subalpine region, Campbell Island, L. C.					
ROSACEÆ.					
Geum sericeum, Kirk. A	..	1	..	..	..
Allied to a Fuegian species					
Acæna sanguisorbæ, Vahl. B	..	1	1	1	1
A. sanguisorbæ var. *antarctica*, var. nov.	..	1	1	1	..
This is the common *Acæna* of the Southern Islands, and seems to me quite distinct from any form found in New Zealand. It was most likely referred to var. *pilosa* by Kirk, to which form, or, as I consider it, species, it bears some resemblance. The leaves are pale-green, but not whitish-green as those of *A. sanguisorbæ* var. *pilosa*, glabrous on upper surface, but with many adpressed hairs on under-surface. Scape almost glabrous, short and hardly raised above the foliage, ± 2·3 cm. long. (In the var. *pilosa* the scapes are raised high above the foliage.) Head ± 8·5 mm. in diameter; calyx-lobes bright-green (in the var. *pilosa* they are more or less reddish), calyx-tube not densely pilose; stamens not exserted, but it may be that this variety is in part diœcious.					
A. sanguisorbæ antarctica can be distinguished at a glance from *A. sanguisorbæ pilosa* by the general aspect, which is chiefly brought about by the colour of the leaves, the length of the scapes, the colour of the calyx-lobes, and the length of the stamens.					
A. adscendens, Vahl. C	..	..	..	..	1
This is stated to occur in New Zealand, but Macquarie Island specimens which I have examined seem to me very different to the New Zealand plant, with which I am well acquainted.					
CRASSULACEÆ.					
Tillæa moschata, D.C. B, C	1	1	1	1	1

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
DROSERACEÆ.					
Drosera stenopetala, Hook. f. B	..	1	..	..	..
HALORAGIDACEÆ.					
Callitriche antarctica, Eugelm. C	1	1	1	1	1
MYRTACEÆ.					
Metrosideros lucida, A. Rich. B	..	1	1?	..	..
Mr. Gordon, who knows this plant quite well, states that he has not seen it in Campbell Island.					
ONAGRACEÆ.					
Epilobium linnæoides, Hook. f. B	..	1	1	1	1
E. confertifolium, Hook. f. A	..	1	1	1?	..
Kirk refers certain New Zealand forms to this species, but Mr. D. Petrie, with whom I fully agree, considers that *E. confertifolium* does not occur in New Zealand proper. The flowers are bright-pink.					
E. nerterioides, A. Cunn. B	..	1	..	..	1
E. alsinoides, A. Cunn. B	..	..	..	1	..
I am not sure that Kirk's identification is correct.					
E. nummularifolium, R. Cunn. B	..	..	..	..	1
Probably this is *E. nerterioides*.					
UMBELLIFERÆ.					
Azorella selago, Hook. f. C	..	..	..	..	1
A. reniformis, Benth. and Hook. A	..	1	1	..	..
Ligusticum latifolium, Hook. f. A	..	1	1	..	..
L. antipodum, Hook. f. A	..	1	1	1	..
L. acutifolium, Kirk. A	1	..	..	..	..
Apium australe, Thouars. B, C	1	..	..	1	..
ARALIACEÆ.					
Panax simplex, Forst. f. B	..	1	..	..	..
Stilbocarpa polaris, A. Gray. A	..	1	1	1	1
Aralia lyallii, Kirk (Armstg.), var. *robusta*, Kirk. A	1	..	..	..	..
I consider this a distinct species, so far as I can judge from the description and my knowledge of *A. lyallii*.					
RUBIACEÆ.					
Coprosma fœtidissima, Forst. B	..	1	1?	..	..
According to Mr. Campbell this does not occur in Campbell Island.					
C. cuneata, Hook. f. B	..	1	1	1	..
C. ciliata, Hook. f. A	..	1	1	1?	..
I am not sure but that a ciliate-leaved *Coprosma* from Westland should be referred to this species. I am not at all certain as to what species the Antipodes Island *Coprosma* should be referred.					
C. repens, Hook. f. B	..	1	1	1	1
Nertera depressa, Banks and Sol. B, C	..	1	1	..	..

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
COMPOSITÆ.					
Lagenophora forsteri, D.C. B	..	1	1	1	..
Olearia lyallii, Hook. f. A	1	1	..	..	..
Celmisia vernicosa, Hook. f. A	..	1	1	..	..
C. chapmanni, Kirk. A	..	..	1	..	..
C. verbascifolia, Hook. f. (Campbell Island, Rathouis)	..	..	1?	..	..
The occurrence of this on Campbell Island seems most unlikely. Mr. Gordon has never seen it.					
Gnaphalium luteo-album, L. (cosmopolitan). B	..	1	..	1	..
Abrotanella spathulata, Hook. f. A	..	1	1	..	..
A. rosulata, Hook. f. A	..	..	1	..	..
Helichrysum prostratum, Hook. f. B	..	1	1	1	..
Cotula plumosa, Hook. f. C	..	1	1	1	1
C. propinqua, Hook. f. A	..	1	1	..	..
C. lanata, Hook. f. A	..	1	1	..	..
C. australis, Hook. f. B	..	..	1	..	..
For occurrence of this on Campbell Island see Buchanan (9, p. 399).					
Pleurophyllum speciosum, Hook. f. A	..	1	1	..	..
P. criniferum, Hook. f. A	..	1	1	1	..
P. hookeri, Buchanan. A	..	1	1	..	1
Senecio stewartiæ, J. B. Armstg. B	1	..	..	..	..
This does not occur either on the actual mainland of New Zealand or on Stewart Island, but on some small islands in close vicinity to this latter.					
S. antipoda, Kirk. A	..	..	..	1	..
Cassinia vauvilliersii, Hook. f. B	..	1	1?	..	..
Mr. Gordon says he has not observed this on Campbell Island, and I certainly did not meet with it.					
Erechtites sp. B	..	1	..	..	..
Enderby Island, L. C.					
Sonchus asper,* Hill (cosmopolitan). B	1	..	..	1	..
If *S. asper littoralis*, Kirk, is the plant which grows on the Snares, then it is the form, or perhaps species, which is confined to New Zealand.					
STYLIDIACEÆ.					
Phyllachne clavigera (F. Muell.), Hook. f. A	..	1	1	..	..
CAMPANULACEÆ.					
Pratia arenaria, Hook. f. A	..	1	..	1	..
Also common in Chatham Island.					

* This and *Cotula dioica* have been collected on the shore of Auckland Island by Dr. R. Koettlitz during the recent visit of the "Discovery." *Cotula dioica* is an addition to the flora of the Southern Islands, but it is not included in my percentages, &c.

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
Ericaceæ.					
Dracophyllum longifolium, R. Br. B .. .. A var. "*retortum*" is figured in (45). Possibly *D. arboreum*, Cockayne, of Chatham Island, is a form of this species.	..	1	1	..	..
D. scoparium, Hook. f. A	..	..	1	..	..
D. [urvilleanum, A. Rich.(?)]. B(?)	..	..	1	..	..
Cyathodes empetrifolia, Hook. f. B	..	1	1	..	..
Myrsinaceæ.					
Suttonia divaricata, Hook. f. B	..	1	1	..	..
Primulaceæ.					
Samolus repens, Pers. B, C	..	1	..	..	..
Gentianaceæ.					
The species are here given as in Kirk (69).					
Gentiana cerina, Hook. f., form *α*, *suberecta*, Kirk. A	..	1	..	..	..
G. cerina, form *β*, *cerina*, Kirk. A	..	1	..	..	..
G. cerina, form *γ*, *concinna*, Kirk. A	..	1	..	..	..
G. antarctica, Kirk. A	..	..	1	..	..
G. antarctica var. *imbricata*, Kirk. A	..	..	1	..	..
G. antipoda, Kirk. A	..	..	..	1	..
Kirk makes some interesting ecological remarks regarding the variation of *G. cerina* according to station, and the above three forms are dependent on their station. Experimental work is required on this head, a not too easy matter, since these gentians are difficult to cultivate.					
Boraginaceæ.					
Myosotis capitata, Hook, f. B	..	1	1?	..	..
M. capitata albiflora. B	1	..	..	..	..
M. antarctica, Hook. f. B(?)	..	..	1	..	..
The flowers are coloured blue in "Flora Antarctica." The series of forms referred to this species in New Zealand have white flowers. Perhaps the Southern Islands plant is a distinct variety or species.					
Scrophulariaceæ.					
Veronica elliptica, Forst. B, C	1	1	1	..	..
[*V. odora*, Hook. f.]	..	1	..	..	..
This, I think, is at most a form of *V. elliptica*.					
V. benthami, Hook. f. A	..	1	1	..	..

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
PLANTAGINACEÆ.					
Plantago aucklandica, Hook. f. A	..	1	..	..	..
P. [*brownii*, Rafin.(?)]. A	..	1	..	..	..
This is the *P. carnosa* figured in the "Flora Antarctica." When growing it bears no resemblance whatever to the plant known as *P. brownii* in the Southern Alps. It much more resembles a species of *Plantago* very common in coastal situations in the neighbourhood of Foveaux Strait, which is probably *P. hamiltonii*, Kirk. The Auckland Island species certainly seems to me distinct from any New Zealand species.					
POLYGONACEÆ.					
Rumex neglectus, Kirk. B	..	1	..	..	..
URTICACEÆ.					
Urtica aucklandica, Hook. f. A	..	1	..	..	..
U. australis, Hook. f. B	..	1	..	1	..
This species is not found on the New Zealand mainland. It occurs, however, on Dog Island and Centre Island, in Foveaux Strait, and it very probably occurs on some one or other of the beaches of Stewart Island. It is common in Chatham Island.					
ORCHIDACEÆ.					
The time of the year being quite unfavourable for obtaining these plants, none were seen by me. This list is merely compiled from Hooker, Kirk, &c.					
Corysanthes rotundifolia, Hook. f. B	..	1	1	1?	..
C. macrantha, Hook. f. B	..	1	..	..	..
Caladenia lyallii, Hook. f. B	..	1	..	..	..
C. bifolia, Hook. f. B	..	1	1	..	..
Chiloglottis cornuta, Hook. f. B	..	1	1	1	..
Lyperanthus antarcticus, Hook. f. B	..	1	..	..	..
Thelymitra longifolia, Forst. B	..	1	..	..	..
T. uniflora, Hook. f. B	..	1	..	..	..
Prasophyllum colensoi, Hook. f. B	..	..	..	1	..
LILIACEÆ.					
Bulbinella rossii, Benth. and Hook. (Hook. f.). A ..	..	1	1	..	..
Astelia linearis, Hook. f. B	..	1	1	..	..
A. linearis subulata, Hook. f. A	..	1	1	..	..
Probably a species.					

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
JUNCACEÆ.					
Juncus antarcticus, Hook. f. B	..	1	1	..	..
J. scheuzerioides, Gaud. B, C	..	1	1	1	..
J. bufonius, L. (cosmopolitan). B, C	1	1	..	..	..
J. planifolius, R. Br. B	1	..	..	..	..
Rostkovia gracilis, Phil. C	..	1	1	..	..
R. sphænocarpa, Desv. B, C	..	..	1	..	..
Luzula crinita, Hook. f. A	..	1	1	1	1
RESTIACEÆ.					
Gaimardia ciliata, Hook. f. B.	..	1	..	..	..
G. pallida, Hook. f. B	..	..	1	..	..
CYPERACEÆ.					
Scirpus aucklandicus (Hook. f.), Bœck. B, C	1?	1	1	1	..
S. cernuus, Vahl. (cosmopolitan). B, C	1	..	..	1	..
S. antarcticus, L. B, C	1	..	..	..	..
Oreobolus pumilio, R. Br. B, C	..	1	1	..	..
Carex ternaria, Forst. f. B	..	1	..	1	..
C. trifida, Cav. B, C	1	1	1	1	..
C. appressa, R. Br. B	..	1	1	1	..
Uncinia riparia, R. Br., var. *pseudorupestris*, Küken. B	..	1	1	1	1
According to a communication from Pastor G. Kükenthal, who is investigating the genus *Carex* for "Das Pflanzenreich," the synonyms of this variety are "*U. rupestris*, Boott., non Raoul, and *U. hookeri*, Boott. Kükenthal also writes, "The true *U. rupestris*, Raoul, is not in the Kew Herbarium. I think that it is identical with *U. nervosa*, Boott.					
GRAMINACEÆ.					
Ehrharta thomsoni, Petrie. B	..	1	..	..	..
Hierochloe redolens, R. Br. B, C	1	..	1	..	..
H. brunonis, Hook. f. A	..	1	1	..	..
Deyeuxia forsteri, Kunth. B	1	..	1	..	..
Agrostis antarctica, Hook. f. C	..	..	1	1	1
A. subulata, Hook. f. A	..	..	1	..	..
Deschampsia cæspitosa, Beauv. (cosmopolitan). B, C	..	1	..	..	..
D. chapmanni, Petrie. A	..	1	..	..	..
D. hookeri, Kirk. B	..	1	1	1	1
D. gracillima, Kirk. A	..	1	..	..	..
D. penicillata, Kirk. A	..	..	..	..	1
Trisetum subspicatum, Beauv. B, C Northern arctic regions.	..	..	1	..	..
Danthonia bromoides, Hook. f. B	..	1	1	..	..
D. australis, Buch. B	..	..	1	..	..
Festuca scoparia, Hook. f. B	1	1	1	1	..
F. contracta, Kirk. A	..	..	..	..	1

—	Snares.	Auckland.	Campbell.	Antipodes.	Macquarie.
Poa foliosa, Hook. f. B	1	1	1	1	1
Not found on the actual mainland, the so-called var. β having been made by Hackel into a species under the name *Poa novæ-zelandiæ* (38).					
P. ramosissima, Hook. f. A	..	1	1	..	..
P. hamiltonii, Kirk. A	..	..	..	..	1
P. breviglumis, Hook. f. A	..	..	1	1	..
P. incrassata, Petrie. A	..	1	..	..	..
P. chathamica, Petrie. A	..	1?	..	..	..
P. [*anceps*, Forst.(?)] A(?)	..	1?	1?	1	..
PTERIDOPHYTA. B.					
Hemitelia smithii, Hook. B	..	1	..	..	..
Hymenophyllum tunbridgense, Sm. B	..	1	..	..	..
H. minimum, A. Rich. B	..	1	..	..	..
H. bivalve, Swartz. B	..	1	..	..	..
H. multifidum, Sw. B	..	1	1	1	..
H. polyanthos, Sw. B	..	1	..	..	..
H. villosum, Col. B	..	1	1	1?	..
H. dilatatum, Sw. B	..	1	..	..	..
H. demissum, Sw. B	..	1	..	..	..
H. flabellatum, Labill. B	..	1	..	..	..
H. javanicum, Spgr. B	..	1	..	..	..
Pteris esculenta, Forst. B, C	..	1?	1	..	..
I did not observe this species.					
P. incisa, Thunb. B, C	..	1	..	1	..
Lomaria procera, Spgl. B, C	..	1	1	1	..
L. discolor, Willd. B	..	1	1	..	..
L. dura, Moore. B	..	1	1	1	..
L. alpina, Spgl. C	..	..	..	1	1
L. fluviatilis. B	..	1	..	..	..
Forest south of Auckland Island, L. C.					
Asplenium mohrioides. C	..	1	..	..	..
A. obtusatum, Forst. B, C	1	1	1	1	..
A. scleropium, Homb. and Jacq. A	..	1	..	..	..
A. bulbiferum, Forst., var. B(?)	..	..	..	1	..
A. flaccidum, Forst. B	..	1	..	..	..
Aspidium vestitum. B, C	..	1	1	1	1
A. cystotegia, Hook. B	..	1	..	..	..
Polypodium (Grammitis) australe, Mett. B, C ..	..	1	1	1	..
P. australe rigida, Homb. and Jacq. A	..	1	..	..	..
P. australe pumila, Armstg. B	..	..	1	..	1
P. grammitidis, R. Br. B, C	..	1	1	..	..
P. rugulosum, Labill. B	..	1	1	..	..
P. (Phymotodes) billardieri, R. Br. B	..	1	1	..	..
Schizæa australis, Gaud. B, C	..	1	..	..	..
Hypolepis millefolium. B	..	..	..	1	..
Todæa superba, Col. B	..	1	..	..	..
Lycopodium varium, R. Br., var. *polaris*, Kirk. B ..	..	1	1	1	1
L. fastigiatum, R. Br. B, C	..	1	1	1	..
L. scariosum, Forst. B, C	..	1	..	..	..
Tmesipteris forsteri, Endlich. B	..	1	..	..	..

VIII. Table showing Percentage of the Different Floral Elements for each of the Southern Islands.

Explanation of Abbreviations used.—End. = found only in one island; End. S.I. = found in more than one island; Fueg. = Fuegian, including those species found also in New Zealand; Fueg. S.I. = Fuegian which do not extend to New Zealand; N.Z. = New Zealand, but excluding the New Zealand – Fuegian species.

Islands.	End.		End. S.I.		Fueg.		Fueg. S.I.		N.Z.		Total.
	Species.	Percentage.	Species.	Percentage.	Species.	Percentage.	Species.	Percentage.	Species.	Percentage.	Species.
Auckland	10	10	29	29	15	15	3	3	46	46	100
Campbell	7	8·6	27	33·3	16	19·9	4	4·9	31	38·2	81
Antipodes	3	7	10	23·2	11	25·6	3	7	19	44	43
Macquarie	3	11	5	18·5	9	33·3	6	22·2	10	37	27
Snares ..	2	9·5	2	9·5	10	47·6	1	4·7	7	33·5	21

IX. Bibliography.

[The numbers correspond with the references in the paper.]

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EXPLANATION OF PLATES XI.–XXIV.

[All the photographs were taken by the author.]

Plate XI.

1. Juvenile leaf of *Panax simplex*, from plant collected at Norman's Inlet, Auckland Island.
3. Five-foliate leaf of *Panax simplex*, from juvenile plant collected at Norman's Inlet, Auckland Island.
4. Ternate leaf of *Panax simplex*, from same shoot as No. 3.
5. Simple leaf from same shoot as 6— Stewart Island juvenile plant of *P. simplex*, collected at Port Pegasus.
6. Cut-leaved juvenile form of *P. simplex*, larger but similar to 1, Port Pegasus, Stewart Island.

[The above figures merely show the outlines of the leaves.]

Plate XII.

Sand-dunes and sandy shore of Enderby Island. The dark patches on the dunes show the close vegetation. Portion of rata forest in left-hand top corner.

Plate XIII.

Interior of rata forest, Auckland Island. The fern is *Aspidium vestitum.*

Plate XIV.

Olearia lyallii forest above cliffs of Ewing Island.

Plate XV.

Olearia lyallii forest coming to near high-water mark, Ewing Island. *D'Urvillæa utilis* washed up on to the shore. Grass-tussock in left-hand bottom corner.

Plate XVI.

Exterior of low rata forest—almost scrub—on Enderby Island. *Suttonia divaricata* in right-hand bottom corner.

Plate XVII.

General view of forest as in Plate XVI., in front of which is grass-tussock 1m. or more tall. North end of Auckland Island in background.

Plate XVIII.

Aristotelia fruticosa, a New Zealand xerophytic shrub, growing at outskirts of a beech forest, Canterbury, South Island.

Plate XIX.

Cliffs of Antipodes Island near the boat-landing. Maritime tussock slope on left.

PLATE XX.

Flat tussock meadow of Antipodes Island. Bog in centre. Inland tussock slope on right.

PLATE XXI.

Aralia lyallii growing near shore, Ruapuke Island, Foveaux Strait.

PLATE XXII.

Veronica lycopodioides after culture for some months in moist air and feeble light. To illustrate "plasticity" of certain New Zealand plants.

PLATE XXIII.

Map of Auckland Islands, Antipodes Islands, and Bounty Islands. (In the map of the Auckland Islands "Musgrave Inlet" should read "Norman Inlet," and *vice versâ*.)

PLATE XXIV.

Map of Campbell Island.

ART. XXVII.—*Abnormal Growth of a Plant of* Phormium colensoi.

By the Right Rev. W. L. WILLIAMS, D.D., Bishop of Waiapu.

Plate XXV.

[*Read before the Auckland Institute, 6th July, 1903.*]

IN the month of February, 1896, having occasion to walk round the rocks at Blackhead, my attention was attracted by a plant of *Phormium colensoi*, growing a little above high-water mark, which was then in seed, the seed-capsules being accompanied with numerous persistent bracts, which were then quite dry. A specimen of this was brought away and sent to the late Professor Kirk. A few seeds which dropped from this specimen were sown, and one of the plants raised from that seed is the subject of this paper.

On this plant in the spring of 1900 one scape appeared, which did not grow to a height of more than about 3 ft. One or two abortive flowers were produced, but instead of more flowers a cluster of buds appeared, each of which produced a number of leaves from 12 in. to 15 in. long. These buds were afterwards cut off and planted, but none of them took root. In 1901 four scapes shot up, the growth of each of which was arrested at the height of about 3½ ft., no flowers being produced, but each scape being crowned with a large cluster of leafy buds, like the scape of the previous year, the leaves being now from 18 in. to 2 ft. long. In 1902 four scapes again appeared, three of which are about 7 ft. high. These all produced flowers and seeds in the normal way, though the flowers

developed irregularly as to time, some of the seeds having ripened early in May, while at the present time (23rd June, 1903) there are capsules which are not yet fully ripe. In the course of the summer the upper portions of these scapes began to be clothed with leaves, which are now from 6 in. to 12 in. long. The growths of 1901 are still fresh and vigorous, one of them having produced, in the early summer, a scape about 18 in. long, which bore a few flowers and ripened seed.

Since the above was written a succession of flowers has been produced upon some of the upper branchlets during the months of August and September.

Art. XXVIII.—*On Abnormal Developments in New Zealand Ferns; with a List of Papers by various Authors on the Ferns of New Zealand.*

By A. Hamilton.

[*Read before the Otago Institute, 13th October, 1903.*]

Plates XXVI., XXVII.

About ten years ago I was gathering specimens near the junction of Morison's Creek with the Leith Stream, and I noticed that the commonest fern in that particular part, *Lomaria fluviatilis*, showed several remarkable variations at the tips of the fronds, in the form of division and cresting. A few specimens were collected for my collection of dried ferns. A few months ago, however, I made a fresh visit to that locality, as I found that the City Corporation were intending to make this particular area the intake for an additional water-supply for Dunedin. I closely examined the area over which the crested fronds were found, and discovered a large proportion of the plants were growing on about a quarter of an acre. A large proportion of this space is covered by cuttings for a road up the creek and a road leading to higher ground. The face of these cuttings has received the spores of several species of ferns mainly belonging to the genus *Lomaria*—*L. fluviatilis*, *L. discolor*, *L. lanceolata*, and *L. procera*—with a few *Asplenium* and *Pteris*. The southerly exposure of the area was evidently favourable to the growth of fern-life, and there was sufficient moisture to insure quick growth. I endeavoured to obtain specimens of small young plants with crested fronds, but was not successful, except in the case of a stray plant of *Lomaria lanceolata*. In fully adult plants of *L. fluviatilis*, probably from ten to twenty years old, judging by the size of the root-stocks and the re-

mains of old fronds, it was easy to find many unusual and beautiful forms of cresting at the tips of the barren fronds.

I took four large plants of *L. fluviatilis* and examined those fronds that were still green, with the following results:—

Plant *a*.—Average length of frond, 30 in. It had twelve barren fronds, ten of which were crested, and six fertile fronds, three of which were crested.

Plant *b*.—Average length of fronds, 15 in. The plant had eight barren fronds in sufficiently good condition to measure, and six of these were crested. The relatively small number of fronds is accounted for by the cattle having eaten off the tops of many, and having otherwise broken down the plants so that the condition of the apex could not be observed.

Plant *c*. — Average length of frond, 19 in. There were seven barren fronds, and of these all were crested. Two fertile fronds were so far perished that it was impossible to say whether they had been normal or not.

Plant *d*.—A large plant from a very wet situation, the average length of fronds 30 in. It had thirty-three barren fronds, of which twenty-four were crested, and sixteen fertile ones, apparently all normal.

I cut this plant up carefully to see if the root-stock could be separated into separate heads carrying crested and non-crested forms separately, but found it only composed of three heads, each carrying crested and non-crested fronds.

These results only show, of course, the proportion of abnormal fronds on the growth of the last season, or possibly two seasons. The dried and rotten fronds of previous years could not be examined as the tips perish so readily.

A specimen of the form of cresting is shown on Plate XXVI. I have no doubt that such a natural sport could be perpetuated and improved upon by cultivation, as the sporiferous fronds have been found divided and crested. I have given several plants to a gentleman who takes an interest in the culture of New Zealand ferns, and he will, I hope, be able to perpetuate, if not improve, the variety. Since finding this form at Morison's Creek I have come across equally good specimens in deep creeks nearer the Waitati Saddle, in the Water of Leith, though not in such profusion.

In thinking over the matter of variation in fronds I remembered noticing an unusual number of abnormalities in the fronds of the common *Lomaria procera*, which covers a large portion of the southern slopes of Signal Hill, and which seems to spring up after every scrub-fire, like the *Pteris* on the hills in the North. On the 3rd September I went out for two hours one afternoon on the hillside with the view of

gathering all the unusual forms that I could see. At that time of year nearly all the fronds of the past season are withered and frosted, and it is only under the high manuka or under the shelter of some rock or bush that fronds fit for examination can be found.

I have tabulated the result of my foraging, and I find that I picked eighty fronds which did not appear to be normal. A very great proportion of all the fronds are what I shall call *depauperate*—that is, the margin of the pinnæ is highly irregular, instead of conforming to the shape of the pinnæ of the normal fronds. This is not peculiar to Signal Hill; the same obtains on nearly all high ground around Dunedin, and requires to be exactly described by an experienced botanical physiologist. Of these I picked a few here and there for future study. I should say that fully 70 per cent. of the fronds of *Lomaria procera* are thus affected.

Another class of abnormal fronds is the case in which the main stipe is divided below the lowest pinna, and has practically two barren fronds on a single stipe. Another class, or perhaps a subdivision of the last, is where the stipe is divided nearer the apex, giving a partly double frond.

The next variation is where the terminal pinna is divided once or many times; and, finally, where one or more of the lateral pinnæ are divided.

Of the eighty fronds brought home there were: Depauperate, 11 (only a few of the most curious were picked); stipe forked below commencement of pinnæ, 15; stipe forked nearer the apex, 12; apical pinna divided or forked more than once, 19; fronds having one lateral pinna forked, 35; fronds having two lateral pinnæ forked, 5; fronds having three lateral pinnæ forked, 2; fronds having four lateral pinnæ forked, 1.

It is evident from the above facts that a careful search will reward the diligent searcher with further varieties; and the experience of English fern-growers has proved that when once a natural sport has been obtained it produces spores from which an unending series of forms can be cultivated. Mr. Field, a veteran collector and observer of New Zealand ferns, has written in the Transactions on the variations in the manner of growth of several species of ferns in the North Island,* and points out that what is taken as a species may vary much in general habit in different localities.

Curiously enough, Mr. Field, although he has had more than half a century in the New Zealand bush in the North

* Field, H. C.: "On the Growth of Ferns; and on a New Fern now first reported." Trans. N.Z. Inst., xxvii., 446, 450.

Island, has stated* that he has never seen any variation such as I have recorded above. Although my modest experience of New Zealand ferns in the bush only dates back to 1877, I have had the good fortune to come across abnormal varieties in many genera and of many species. I am referring now to abnormal varieties in the pinnæ, and not to such varieties as are recognised by the species-maker as a rule.

There is, however, one well-marked variety, discovered by me in the Whanakino Creek, in the ranges at the back of the Hawke's Bay Provincial District, which has received a name and description from the late Rev. W. Colenso. It is a form of *Polypodium pennigerum* var. *hamiltonianum*, Col., which has remained constant under cultivation for years.

A variety of *Lomaria*, described by the late T. H. Potts as *Lomaria duplicata*,† is only a form of *Lomaria procera* in which the stipe is persistently divided.

A form of a rather uncommon fern, *Asplenium umbrosum*, was described by the late Thomas Kirk,‡ from Takaka, Nelson, where it was found by Mr. J. McKenna Campbell, as var. *tenuifolium*. It is mentioned that the plant has a pleasant fragrance, a peculiarity which it shares with a *Doodia* and with *Polypodium pustulatum* in New Zealand. There are many species in various parts of the world which are fragrant, and retain their odour for a long time in the dried state. One species, *Polypodium phymatodes*, is used largely in the Polynesian Islands for scenting the cocoanut-oil used for the human body. The odour of all these ferns is apparently due to oil-glands in the substance of the fronds. In England many of the *Lastreas* are scented.

It is not often that sports are observed in tree-ferns, but Mr. H. Matthews, the Government Forester, informs me that some years ago he sent to Kew Gardens a fine specimen of *Dicksonia squarrosa* which had all the pinnæ forked or crested. This plant came from the Catlin's River district.

Other species which I have found in a crested condition in the North Island are: *Adiantum cunninghamii*, Hk. Of this I obtained two crested plants on the limestone rocks at the gorge of the river at Puketapu. These plants were grown in Mr. H. S. Tiffen's fernery, and when I last saw them were quite constant.

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* Journ. of Botany, xxi., 1883, p. 140.

† Potts, T. H.: "Notes on a *Lomaria* collected in the Malvern District (*L. duplicata*)." Trans. N.Z. Inst., ix., 491; 1876.

‡ T. Kirk: "On a Remarkable Variety of *Aspl. umbrosum*, J. Sm." Trans. N.Z. Inst., xxiii., 424–425; 1890.

Cheilanthes tenuifolia or *sieberi:* This is an extremely variable fern in the neighbourhood of Petane, Hawke's Bay, and I have found many divided and otherwise irregular fronds. At one time or another I have found abnormal fronds of nearly all the common *Lomarias*, especially *L. procera*, *L. discolor*, and *L. alpina*.

In *Asplenium* I have gathered *A. trichomanes* beautifully crested on the rocks near Petane, and near Waipawa, in a small patch of bush, a very curious form of *A. flabellifolium*. Mr. A. C. Purdie had a well-crested form of *A. falcatum*, originally found on Quarantine Island, near Port Chalmers, and I have seen other plants in cultivation in Dunedin. I have not gathered many abnormal fronds of *Aspidium*, though this is a group in which many sports may be looked for. I have specimens of *A. aculeatum* with divided fronds, and have seen a very remarkable form said to have been obtained on Saddle Hill, in the Taieri district of Otago, which carried young plants on the under-surface of every frond about 6 in. from the tip, the fronds being about 3 ft. long. On the Waitati Saddle I have seen plants of this fern which showed a bend or weakness in the otherwise normal frond at just about the same position on the frond. The plant was cultivated for years by the late Mr. A. C. Purdie, but has, I am afraid, passed out of existence.*

One of the most striking forms that I have seen was brought to me by Mr. C. W. Adams from the Catlin's River Bush. It was a large mass of *Polypodium billardieri* much crested. I had this plant in cultivation for some years, but one very severe winter it died out. I have seen a similar form in a nurseryman's collection in Christchurch.

Polypodium tenellum also sports into crested forms, one of which I gathered at Tongoio.

In the neighbourhood of Dunedin the *Leptopteris hymenophylloides* is usually much more lanceolate in form of frond than in the North, and appears to be affected by some fungoid(?) disease which thickens the pinnules irregularly, making them crisp and brittle and markedly dissimilar to the other pinnules, quite spoiling the feathery appearance of the frond.

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* Since writing the above note I have seen other plants of this variety. In the frond now before me, from a small plant with fronds averaging about 12 in., the young bulbils are aggregated in a bunch 1 in. from the apex of the frond. Some of the bulbils have aborted, but two have developed fronds $\frac{3}{4}$ in. in length, and two of these carry fully developed sporangia on every pinnule. The frond only developes these bulbils in the autumn. The main bunch of bulbils is at the base of a pinna on the right side of the main rhachis, but each of the two lower pinnæ on the other side have a less developed bulbil at a point where they form the rhachis.

In view of the number of crested, divided, and otherwise abnormal ferns which I have seen, it was somewhat of a surprise to me to find that Mr. Field, in a note in the "Journal of Botany,"* says, "I have never met with a crested New Zealand fern, and only once or twice with a depauperate one, while variations in colour are common." I think if special search were made for crested forms it is quite possible that some of great interest and beauty may be found, and if cultivated with skill there are endless possibilities in the future, as it is now a well-established fact that crested ferns rarely revert to their normal state when raised from spores, although occasionally a further distinct form will present itself.

For nearly forty years a small group of English fern-growers have been working at the task of raising plants from spores of plants found wild under natural conditions, and a large number of facts have been gathered which wait a master hand for deductions. Although so much was done by Darwin in his researches on animals and plants under domestication, in which he brings together a vast host of facts derived from the vegetable and animal kingdom, the record anent ferns, which in some respects present unique powers of variation, is summed up in a solitary short remark about the power of spores taken from abnormal fronds to reproduce the abnormal character. Those who wish to take up some branch of botanical study will find a wealth of material at hand, either in a scientific study of the behaviour of the prothalli under various conditions in the living state, or by the microscopical investigation of the anatomy of the leaf-stalk and the dispositions of the stelæ. This latter character has been investigated lately in the hope of finding more absolute characters for the discrimination of genera. Much interesting detail will also be found in the structure of the filmy ferns.

The quest for naturally crested or divided ferns for cultivation will add to the enjoyment of many a walk or scramble in the bush, and careful selection of plants raised from natural sports will amply reward the care and trouble required to produce good results in this as in everything else.

Search should also be made for examples of apospory. I have not yet seen an example in New Zealand ferns, but in an Annual Report of the Colonial Museum there is an entry which may be a record of this: "1754.—Feb. 24, 1887.—Fern, *Asplenium obtusatum*, supposed to be a new variety; proliferous on the upper surface. Sent by Miss Marchant."

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*Field, H. C.: "Variation in New Zealand Ferns." "Journal of Botany," xxi., 140, 141; 1883.

[NOTE.—In the following list "Trans." means the "Transactions of the New Zealand Institute."]

Author.	Title.	Name, &c., of Publication.
Armstrong, J. B...	On a Natural Arrangement of the New Zealand Ferns	Trans. xiii. 360; 1880.
Baker, J. G., F.R.S.	A Summary of New Ferns which have been discovered or described since 1874	Ann. of Botany, 181; 1891.
Buchanan, John, F.L.S.	On the Root-stock of *Marattia fraxinea*	Journ. Linn. Soc. xvi. 2. Trans. ix. 527–529; 1876.
	On a Remarkable Branching Specimen of *Hemitelia smithii*	Trans. xix. 217, pl. xii. and xiii.; 1886.
	On the Flowers, Plants, and Ferns of the Chatham Islands	Trans. vii. 333; 1874.
Cheeseman, T. F., F.L.S.	Description of a New Species of *Hymenophyllum*	„ viii. 330; 1875.
	Description of a New Species of *Polypodium*	„ x. 356; 1877.
	Notice of the Discovery of *Asplenium japonicum*, a Fern new to the New Zealand Flora	„ xxii. 448; 1889.
	A Description of some New Ferns lately discovered in New Zealand	The Tasmanian Journal, i. 375; 1842.
Colenso, Rev. W., F.R.S.	Description of Two New Zealand Ferns believed to be new to Science	Trans. xi. 429; 1878.
	The Ferns of Scinde Island ..	„ xiii. 370; 1880.
	On some New and Undescribed New Zealand Ferns	„ xiii. 376; 1880.
	A Description of Four New Ferns from our New Zealand Forests	„ xv. 304; 1882.
	On a Large Number of Ferns noticed in a Small Area in the New Zealand Forests, in the Seventy-mile Bush, between Norsewood and Dannevirke, in the Province of Hawke's Bay	„ xv. 311; 1882.
	A few Observations on the Tree-ferns of New Zealand, with Particular Reference to their Peculiar Epiphytes, their Habits, and their Mode of Growth	„ xix. 252; 1886.
	On Newly Discovered and Imperfectly Known Ferns of New Zealand, with Critical Observations	„ xx. 188; 1887.
	Description of Three Newly Discovered New Zealand Ferns	„ xxiv. 394; 1891.
	A Description of a few Lately Discovered Rare Indigenous Ferns	„ xxv. 319; 1892.

Author.	Title.	Name, &c., of Publication.
Colenso, Rev. W., F.R.S.	A Description of Two New Ferns and One New *Lycopodium* lately detected in our New Zealand Forests	Trans. xxvii. 399 ; 1894.
	A Description of Two New Ferns, a New *Lycopodium*, and a New Moss, &c.	„ xxviii. 615 ; 1895.
	Description of Three New Ferns, believed to be undescribed, discovered more than Fifty Years ago in the Northern District of New Zealand	„ xxviii. 618 ; 1895.
	A Description of some New Indigenous New Zealand Forest Ferns	„ xxix. 414 ; 1896.
	A Description of some Newly Discovered New Zealand Ferns	„ xxxi. 263 ; 1898.
Enys, John ..	On Recent Changes in the Nomenclature of New Zealand Ferns	„ iii. 213 ; 1870.
	On the Occurrence of *Botrychium lunaria*, Swb. (Moonwort), in New Zealand	„ xvi. 363 ; 1883.
Field, H. C. ..	Notes on New Zealand Ferns ..	N.Z. Journ. of Sc. i. 128.
	Variation in New Zealand Ferns	Journ. of Botany, xxi. 140 ; 1883.
	On the Growth of Ferns ; and on a New Fern now first reported	Trans. xxvii. 446 ; 1894.
	On Curious Forms of New Zealand Ferns	„ xxx. 434 ; 1897.
	Notes on Hybrid Ferns ..	„ xxxv. ; 1902.
Hamilton, A. ..	Notes on some New Zealand Ferns	„ xxii. 493 ; 1889.
	Notes on a Branched Specimen of a Tree-fern, *Hemitelia smithii*	„ xxviii. 622 ; 1895.
Hector, Sir James	Corrected List of New Zealand Ferns	„ iii. (at end of vol.) ; 1871.
Kingsley, R. I. ..	On a Remarkable Variety of *Lomaria lanceolata*	„ xxv. 306 ; 1892.
Kirk, Thos., F.L.S.	Notice of a Remarkable Arborescent Fern on *Ngongotaha*	„ v. 347 ; 1872.
	On the Specific Characters of *Dicksonia antarctica*, Br., and *D. lanata*, Col.	„ v. 345 ; 1872.
	On the New Zealand Forms of *Cheilanthes*	„ vi. 247 ; 1873.
	On *Nephrodium pentangularum*	Proc. N.Z. Inst. x. 531 ; 1877.
	On *Hymenophyllum armstrongi*	Proc. N.Z. Inst. x. 532 ; 1877.
	Description of a New Species of *Hymenophyllum*	Trans. x. 394 ; 1877.
	On *Lindsaya viridis*, Col. ..	„ x. 396 ; 1877.

Author.	Title.	Name, &c., of Publication.
Kirk, Thos., F.L.S.	On *Nephrodium decompositum*, Br., and *N. glabellum*, A. Cunn.	Trans. x. 398; 1877.
	On *Hymenophyllum villosum*, Col.	„ x. 395; 1877.
	Description of a New Species of *Hymenophyllum*	„ xi. 457, pl. xix.; 1878.
	On the Ferns and Fern Allies of Stewart Island	„ xvii. 225; 1884.
	On a Remarkable Variety of *Asplenium umbrosum*, J. Sm.	„ xxiii. 424; 1890.
Potts, T. H. ..	Habits of *Filices* observed about the Malvern Hills, near the Gorge of the Rakaia River, Canterbury, New Zealand	Journ. Linn. Soc. (Bot.) xv. 423; 1876.
	Notes on Ferns	Trans. x. 358; 1877.
	Notes on a *Lomaria* collected in the Malvern District	„ ix. 491; 1876.
Ralph, T. S.	On the Arborescent Ferns of New Zealand	Proc. Linn. Soc. iii. 163.
Thomson, P. ..	Notes on Rare Ferns	Proc. N.Z. Inst. vii. 540; 1874.

ART. XXIX.—*List of Papers and Notices on Botanical Subjects in the "Transactions of the New Zealand Institute" and other Publications.*

By A. HAMILTON.

[*Laid before the Otago Institute, 13th October, 1903.*]

[NOTE.—In the following list "Trans." means the "Transactions of the New Zealand Institute."]

Author.	Title.	Name, &c., of Publication.
Anon.	Plants injured by Frost at the Hutt	Proc. N.Z. Inst. viii. 411; 1875.
	Deciduous Trees: as to the Desirability of their being planted in the Botanical Gardens	Proc. N.Z. Inst. viii. 412; 1875.
	Report of a Committee of the Philosophical Institute of Canterbury on Native and Introduced Grasses, with Appendices	Trans. iv. 292; 1871.
Adams, J. ..	On the Botany of the Thames Goldfields	„ xvi. 385; 1883.
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IV.—GEOLOGY.

Art. XXX.—*On the Subdivision of the Lower Mesozoic Rocks of New Zealand.*

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[*Read before the Otago Institute, 11th August, 1903.*]

Plates XXVIII. to XXXI.

Introduction.

An examination of the Trias in Nelson, Southland, and alpine Canterbury has led me to the conclusion that the subdivision and correlation of the horizons of this formation present a much more difficult problem than hitherto supposed. Not only do the rocks occur in many disconnected basins, but even in what appears to have been a continuous basin the strata have been so wasted by denudation or disturbed that it is often impossible upon stratigraphical grounds to correlate group with group except within a very limited area. To these difficulties there is added a wonderful uniformity of life throughout the system; and, although the assemblages of life in claystone and sandstone often possess distinctive forms, there is evidence in some places that repetitions of similar conditions of deposition had been attended with a reappearance of the life characteristic of those conditions.

The minor subdivisions of a formation are only of local value when the limits of characteristic life and stratigraphical connection can be seen to coincide. It is evident that a classification is of little value that follows too closely the great subdivisions as they occur in Europe, subdivisions, perchance, grouped on the mere presence of a few genera whose association in a particular horizon may have been the result of peculiar local conditions prevailing at the time of deposition.

It has been shown, both by geologists and palæontologists alike, that there is a singular lack of homotaxial parallelism between the marine and terrestrial organisms of Australasia and Europe, which, moreover, seems to become more marked and significant as we advance through the Mesozoic and Tertiary periods up to the present time. For example, there is a greater characteristic relationship between the Secondary flora of Australia and the Carboniferous of Europe than there is

between the known Carboniferous floras of these respective regions; or, to quote a more striking illustration, the Miocene floras of New Zealand and Tasmania, consisting principally of oaks, elms, beeches, alders, laurels, &c., show a closer relationship to the existing vegetation of Europe than to the present floras of these islands.

As would naturally be expected, the marine faunas show a closer parallelism than the floras, a fact probably due to the greater facilities for rapid diffusion possessed by marine inhabitants in a continuous sea compared with the slower diffusion of terrestrial organisms checked by physical obstructions such as wide stretches of sea and mountain-chains.

The true explanation of this seeming lack of parallelism of life in geologic time is at present a subject for much conjecture and speculation, and doubtless possesses a significance which is not now very obvious to us.

The theory which is thought to satisfy our present knowledge of the facts is that which supposes that the Southern Hemisphere was the cradle of organic life, from which life gradually diffused itself northward by a process of slow migration, differentiated in its progress by accidents of climate and changes in the distribution of land and water.

Attractive as such a theory must be to southern geologists, I am inclined for my own part, after a perusal of recent discoveries in arctic Europe and America, to favour the existence of two independent and widely separated centres of distribution, from which migration slowly radiated into the far-distant regions where types of two distinct ages appear to commingle.

The notorious likeness existing between the marine faunas of the different geological periods in the Southern Hemisphere with the faunas of the corresponding periods in the Northern Hemisphere, from the Cambrian, when the first assemblage of life suddenly burst upon the geological horizon—life that in many respects was complex and comparatively highly organized, whose appearance was unexpected and perplexing because there were no known probable ancestors—from then upward to the close of the Tertiary, this likeness may be held to support the bipolar theory of distribution.

The rate of dispersion, as pointed out by Huxley, Wallace, and other writers, is governed by two dominant factors, of which the position of the centre of origin of each organic unit is one, and the distribution of land and water at the time of dispersion the other. Moreover, in a mixed fauna the powers of migration would not be equal, nor the ability to withstand varying climatic and other adverse conditions. Hence the rate of advance would be unequal; but of this we have no certain evidence. On the contrary, it is probable that the faunas of the different geological periods were similar and

universal throughout the globe in the Palæozoic and Secondary epochs, and that differentiation began with the dawn of present life in the early Eocene. But this contention brings us no nearer the solution of the problem of dispersion, and throws no light on the perplexing difficulties which surround the processes of migration.

Furthermore, it is well known to palæontologists that at certain geological epochs, apparently throughout the world, there was a sudden appearance of animals and plants belonging to orders, and even sub-orders, that were not represented by any probable ancestors in older strata. For example, there was the sudden and almost, if not quite, simultaneous appearance in the Upper Cretaceous of acanthopterygian fishes and dicotyledonous angiospermous plants, now the common existing types throughout the globe.

Dispersion to the remoter parts from the centre of origin, or even to the meeting-points from two or more centres of migration, would occupy countless ages measured by our telluric standard of time. A thousand years is but a fraction of a geologic day; and a migration starting at the dawn of a new day would probably reach the remotest regions before the advent of the coming day.

Considering the question of distribution over wide areas from a biological standpoint, it seems unlikely that all species originated in one particular hemisphere. On the contrary, it is probable that some species originated in the Northern Hemisphere and other species in the Southern.

If we entertain the unicentral theory of origin we must suppose that migration progressed in a succession of great waves; that each wave encountered no insuperable barrier to its forward movement; that each wave maintained its distinctive characteristics notwithstanding the diverse life, latitude, and climate encountered in travelling from one hemisphere to the other; and, further, that each wave was endowed with a migratory instinct that impelled it forward through uncongenial latitudes until it finally arrived at its natural habitat. The problem of the distribution of life is surrounded with many difficulties. Existing conditions are doubtless a reflection of the past, and until we are able to explain the present there seems little hope of unravelling the more tangled problems of geologic time.

There is considerable evidence in favour of the belief that there existed a synchronous parallelism of life in both hemispheres—that is, in corresponding biological provinces and bathymetrical horizons—up till later geological times, when the extreme differentiations of modern types became the dominant inhabitants of the globe.

It is, at any rate, certain that the continuous succession of

fossiliferous marine formations in both hemispheres throughout the geological record does not leave much room for chronological divergence; and in applying European time-names against the place-names of our New Zealand formations we are pursuing a course that seems to be in no way inconsistent with the facts that are known relating to the distribution of life in the different geological formations.

Present Classifications.

At the present time we have two classifications of the Lower Mesozoic and Upper Palæozoic rocks of New Zealand —namely, that formulated in 1878 by Mr. S. Herbert Cox, F.G.S., late Government Assistant Geologist,* and that by Captain Hutton in 1899.†

In his classification of 1873 Hutton placed the Maitai series in the Lower Jurassic period; but in his classification of 1899, in deference to the opinion of the Director of the Geological Survey, he transferred it to the Permo-carboniferous.‡ I have shown in another paper that the Maitai series must be referred back to the Jurassic system, where it was originally placed by Captain Hutton in 1875.

Mr. Cox, in his excellent geological survey of the Hokonui Mountains, in Southland, in 1877 (in which he was assisted by Mr. McKay), subdivided the Lower Mesozoic rocks into seventy-three horizons, which he subsequently gathered into seven groups or series of beds, as follows:—

Upper Oolite	Mataura series.
Middle Oolite	Putataka series.
Lower Oolite	Flag Hill series.
Lias	Bastion series.
Upper Trias (Rhætic)	Otapiri series.
Middle Trias	Wairoa series.
Permian	Kaihiku series.

In Captain Hutton's classification of 1899 the Lower Mesozoic rocks are grouped as follows:—

Hokonui System—	
Mataura series	Lower Jurassic.
Wairoa series	Triassic.

Taking the Jurassic rocks first, it is apparent that the "Mataura series" of Cox and the "Mataura series" of Hutton differ very widely in their meaning. In Captain Hutton's table the Mataura series includes the whole of the Jurassic rocks, and in this respect is the same as the Mataura

* Reps. Geol. Expl., 1877–78, p. 28.
† Hutton, Trans. N.Z. Inst., 1899, vol. xxxii., p. 183.
‡ Hutton, *l.c.*, p. 183.

series of Dr. Lindsay, and of Sir James Hector up till 1873. On the other hand, the Mataura series of Mr. Cox includes only the higher beds of the Jurassic system.

The same divergence is also seen in respect to the Wairoa series of Hutton and Cox. With Captain Hutton the Wairoa series includes all the Triassic and Permian of Cox and Hector, while the Wairoa series of Cox embraces only the beds of the Middle Trias.

In 1886, acting under the instructions of the Director of the Geological Survey, I revised the work of Cox in the Hokonui Hills, and discovered that his Mataura and Flag Hill series referred to the same group of beds.* His Putataka series I was unable to locate as a separate group.

At the time of my examination of the Hokonuis in 1886 I was convinced that Mr. Cox had attempted a subdivision that could not be maintained, not only because of the overlapping of his own groups, but also for the reason that his groups were not sufficiently defined either on stratigraphical or palæontological grounds to be of service for correlative purposes.

An examination of the Nelson Trias having shown the subsequent date of the Maitai formation, the way seemed clear for a rearrangement of the Lower Mesozoic and Upper Palæozoic formations on a broader and safer basis than that employed by Cox in 1878. With that object in view I have made a special examination of the typical sections of the Trias at Nugget Point, North Otago, Upper Rangitata, and Nelson, so as to gather sufficient data to enable me to arrange the different beds in distinctive groups of correlative value.

After a study of the characteristic features of each locality, I have finally selected the Shaw Bay section at Nugget Point, on account of its stratigraphical clearness and numerous marine zones, as the most typical for the subdivision of the Trias and associated beds.

The classifications of Captain Hutton, Mr. Cox, and of the author are shown below in tabulated form :—

Hutton, 1899.	Cox, 1878.	Park, 1903.
Mataura series (Jurassic)	Mataura series ..	1. Mataura series.
	Putataka series ..	
	Flag Hill series ..	
	Bastion series ..	
Wairoa series (Triassic)	Otapiri series ..	2. Shaw Bay series—
	Wairoa series ..	(*a.*) *Athyris* or *Clavigera* beds.
	Oreti series ..	(*b.*) *Mytilus* and *Monotis* beds.
	Kaihiku series ..	(*c.*) *Trigonia* beds.
		(*d.*) *Halobia* beds.
		(*e.*) *Spiriferina* beds.
		(*f.*) Nugget Point plant beds.

* Park, Reps. Geol. Expl., 1886–87, p. 146.

Nugget Point District, Otago.

From the promontory on which Nugget Point Lighthouse stands southward to False Island, at the mouth of Catlin's River, in a distance of nearly four miles, there is exposed along the coast-line a thickness of over 18,000 ft. of strata, forming a continuous succession of beds dipping to the south-west at angles that are always very high. South of Catlin's River the higher beds occur in gently undulating folds, and in this manner pass southward toward Waikawa.

This great assemblage of beds consists of claystones, sandstones, greywacke, and conglomerates, occurring sometimes in thin alternating layers, sometimes in thick beds. Organic remains are not wanting, but are seldom abundant. Plant-remains, generally broken and fragmentary, are scattered from the base to the summit, and in the higher beds at Catlin's large masses of silicified driftwood are not uncommon. Marine shells occur at wide intervals, but are never plentiful except in a few of the lower zones in Shaw Bay, which is now locally known as Roaring Bay.

The character of the sediments and contained fossils clearly indicate that fluvio-marine or estuarine conditions prevailed during the deposition of these beds; and the abundance of granite and related rocks in the lower conglomerates tends to show that the area of erosion whose dissection provided the materials lay to the south-west, probably in the direction of Stewart Island.

The fossils and continuous succession of stratified sediments prove that deposition extended uninterruptedly from Upper Palæozoic to Jurassic times.

The lower beds at the north end of Shaw Bay are intruded by a narrow dyke of porphyrite, and excepting this the whole system is singularly free from evidences of contemporary volcanic activity.

The rocks exposed on the coast-line between Nugget Point and the south head of Shaw Bay, embracing a thickness of nearly 5,000 ft. of strata, belong to the Trias and Upper Palæozoic periods, and the remaining 13,000 ft., lying between the south head of Shaw Bay and Catlin's River, to the Jurassic.

In 1873 Mr. McKay reported the existence in this district of a "*Productus* formation,"* and my first object was to locate this formation, with the view of ascertaining its relation to the Trias. I made a careful examination of the so-called *Productus* beds, and was unable to discover any fossils that

* Reps. Geol. Expl., 1872–73, pp. 63–65.

could be referred to the genus *Productus*. I was therefore compelled to conclude that an error had been made in the determination of the genus.

Before discussing the classification of the Lower Mesozoic rocks in its wider aspect, I shall first detail the sequence and fossil contents of the different beds as we find them exposed at Shaw Bay and Catlin's River and in the typical Trias sections at Nelson and Upper Rangitata, in order that the facts upon which my subdivisions are based may be placed on record. In my examination of the Nugget Point and Catlin's River sections I was accompanied by Mr. A. Hamilton, Director of the Colonial Museum, to whom I was indebted for much valuable assistance in the collection and identification of the fossils.

Previous Geological Examinations.—The Nugget Point district, so far as I can gather, was first geologically examined in 1869 by Dr. W. Lauder Lindsay, who classified the rocks in Shaw—that is, Roaring—Bay as Triassic. Mr. McKay, in 1873, made extensive collections of fossils here for the New Zealand Geological Department, but in his report he does not refer the rocks to any particular age. However, the Director of the Department, in referring to Mr. McKay's collections in the Sixth Annual Report of the New Zealand Institute, considered that the fossils indicated a range from Jurassic to Upper Carboniferous.* The next examination of this district was made in the summer of 1874 by Captain Hutton, F.R.S., who grouped the Shaw Bay beds with his Putataka formation of Lower Jurassic age.† Since that date no further geological examination has been made of this district till the present year, covering an interval of twenty-nine years.

Kaka Point to Hay's Gap.

The Trias rocks are well exposed at Kaka Point and many places on the beach before Hay's Gap is reached, but the outcrops are small and so isolated by stretches of sand that no continuous section can be obtained. For that reason no time was spent in making observations where so much obscurity existed, and where the results could not be other than doubtful and possibly conflicting.

From the beds of Wiltshire Beach McKay collected what he calls a "spirifer," but from his description it was probably a species of *Spiriferina* which I found there associated with *Halobia*, *Rhynchonella*, &c.‡

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* Trans. and Proc. N.Z. Inst., 1875, p. 564.
† "Geology of Otago," 1875, p. 43.
‡ *L.c.*, p. 69.

In the claystones forming the first line of low reefs on the beach south of Campbell's Creek I identified *Halobia* and *Spiriferina*, which would indicate a repetition of the Wiltshire beds in that direction.

Hay's Gap to Nugget Point.

The distance between these points is about two miles, the direction from Hay's Gap for the first mile being almost due south (true meridian), and thence, for the second mile, south-east.

At Hay's Gap the Trias rocks consist of sandstones and claystones, in places alternating in thin laminæ, often highly indurated, jointed and seamed with veins of iron-peroxide. Their strike is E.–W., and the dip south at an angle of 58°. Some 5 chains south of the Gap the strike changes to a direction between E. and E.N.E., with a nearly S.S.E. dip at an angle of 49°; at 6 chains south the strike is about E.S.E.–W.N.W., and the dip nearly S.S.W. at an angle of 78°; while at a distance of 7½ chains the strike is exactly between E. and E.S.E., with the dip still southerly at an angle of 57°.

Thus in a distance of less than 170 yards the strike has changed through an arc of about 30°. The nipping of the beds caused by this sudden change of strike has resulted in a steepening of the dip towards the centre of the nip. Proceeding southward, the strike bends still more to the southward, and at a distance of half a mile from the Gap is N.W.–S.E., and the dip S.W. at an angle of 42°.

Towards the Nuggets the sandstones become coarse in texture, and in places assume the character of greywacke. They form high rocky points and numerous isolated flat reefs on the beach below high-water mark, separated by stretches of sand.

Immediately north of "Boat-landing" the strike varies between N.W. and W.N.W., while the dip is still southerly at angles generally about 65°.

At the point where the road leading to the lighthouse leaves the beach—that is, about 300 yards south-east of Boat-landing—the strata are intruded by a dyke of augite porphyrite which is well exposed in the south side of the road-cutting.

This dyke is of especial interest, as it is the only igneous rock found associated with the Trias formation in this district. It runs almost parallel with the bedding-planes of the enclosing rocks, and can be traced across the saddle into Shaw Bay, a distance of 50 chains. Near Boat-landing it is about 9 ft. thick, but in two places on the ridge dividing Boat-

landing from Shaw Bay it bulges out into great lentil-shaped masses resembling the "laccolites" of Gilbert.

The actual line of contact between the porphyrite and sandstone is clearly exposed in the road-cuttings, and, so far as can be determined, the latter seems to have suffered very little alteration, the only noticeable difference being a somewhat greater degree of induration than elsewhere.

At the north head of Roaring Bay the dyke throws out ramifying branches into the enclosing sandstone.

The porphyrite is granitoid in texture, and weathers to a soft crumbling yellowish earthy brown rock of a dark greyish-green or blue colour, in which the large well-developed phenocrysts of plagioclase become conspicuous when partially kaolinised. It is tough, but not hard, and ought to form a building-stone of superior quality.

In polarised light, the rock is seen to be composed principally of plagioclase, almost to the exclusion of the augite. The latter surrounds the feldspars like a cementing medium, filling the interspaces and consequently occurring mostly as narrow irregular aggregates.

The plagioclase is generally kaolinised, opaque, and turbid. The augite is mostly altered to greenish serpentinous matter and secondary magnetite.

At the point where the road leading to the lighthouse leaves the beach, near Boat-landing, there is a bed of claystone a few feet below the dyke which contains a considerable number of marine forms in a fair state of preservation, occurring principally as casts. Among the genera identified here were *Spiriferina* (*Psioidea* of Hector), *Spiriferina* (two sp.), *Epithyris*, *Rhynchonella*, and *Pleurotomaria*. Besides these, fragments of a bivalve shell resembling *Modiolopsis* were not uncommon.

This fossiliferous horizon is of especial value, as its contents establish the Triassic or Permo-triassic age of the formation, and enable the position of the associated beds to be correlated with the Nelson and Southland Lower Trias or Permian beds.

In the sandstones and underlying the *Spiriferina* beds there is a thin stratum of indurated sandstone crowded in a few places with casts of single valves of a thin bivalve shell. On the surface of rounded boulders, when worn at right angles to the plane of deposition, the casts are seen in section. The profile of the single valves gives a concave appearance somewhat resembling the ventral valve of a *Productus*, and the resemblance to that genus becomes more deceptive when two valves happen to fit into each other.

The casts are those of a very thin gibbose conchiferous shell from 0·5 in. to 0·75 in. high and about the same width.

The remains are too fragmentary even for generic identification.

The *Spiriferina* beds are underlain in descending order by sandstones, often coarse and gritty, and sandstones and claystones alternating in thin laminæ. The latter form the "Nuggets" and the promontory on which the lighthouse stands. Here the beds strike W.N.W. – E.S.E., and dip S.S.W. at very high angles, at places becoming nearly vertical.

On the islet, in the centre of the Nugget group of rocks, the strata are sharply folded and pinched.

In the road-cutting leading to the lighthouse, at a point about 15 chains beyond the keeper's house, the strike of the beds is between E. and E.S.E., and the dip about S.S.W. at an angle of 70°. Here the sandstones are interbedded with beds of soft shaly claystone containing numerous plant-remains, but too broken and fragmentary to be identified. The plant beds are about 850 ft. below *Spiriferina* beds.

Shaw Bay Section.

From the head of Shaw Bay to the headland separating that bay from Sandy Bay, a distance of half a mile, the strike of the beds is W.N.W. – E.S.E. almost without variation, and the dip continuously S.S.W. at very high angles, generally between 75° and 85°.

The coast-line trends almost at right angles to the strike of the beds, and, the angle of dip being high, bed succeeds bed with wonderful regularity, appearing in the sea-cliffs which enclose the bay as clearly defined as books standing on a shelf.

There is exposed along this line of section a thickness of fully 2,500 ft. of strata in one continuous sequence, forming the most complete assemblage of Lower Mesozoic rocks in New Zealand, singularly free from faults or complicated foldings that might cause obscurity or lead to doubtful interpretation. Furthermore, the fossiliferous zones are numerous, and so distinctive as to be easily recognised.

Beginning at the north end of Shaw Bay, the beds exposed along this line of section and their approximate thickness are as follows in ascending order:—

1. Thin laminated claystones and sandstones with plant-remains, probably 200 ft. thick.
2. Indurated sandstones and greywacke, 150 ft.
3. *Spiriferina* beds—dark-blue claystones, 100 ft.
4. Porphyrite dyke.
5. Greywacke.
6. *Halobia* beds about 210 ft. thick—crumbling claystones containing *Halobia lommeli*, Wissm., *Retzia*, *Epithyris*. Seen in road-cutting descending to the bay.

7. Sandstones and claystones, 250 ft., not exposed on beach.
8. Breccia-conglomerate, angle of dip 77°, 20 ft.
9. Highly indurated claystones, 55 ft.
10. Hard greywacke, 15 ft.
11. Thinly laminated claystones and sandstones, 24 ft.
12. Breccia-conglomerate, slaty and granitic, 27 ft.
13. Gritty sandstone, 15 ft.
14. Indurated sandstones with occasional beds of claystone, 200 ft., nearly vertical.
15. Granitic conglomerate, 10 in. thick; angle of dip 86°.
16. Indurated claystone, 50 ft.
17. *Trigonia* bed—claystones, 10 ft. Contains an ammonoid shell, *Trigonia*, *Pleurotomaria*, *Terebratula*, *Pentacrinus*, &c.
18. Sandstones and claystones with subordinate beds of gritty sandstone, 450 ft.
19. Oyster and *Mytilus* bed, 29 ft.; angle of dip 78°.
20. Coarse sandstones, 600 ft.
21. *Athyris* beds, 10 ft.—sandstones containing *Athyris* (*Clavigera* of Hector), *Spiriferina* (*Rastelligera* of Hector).
22. Plant beds—sandstones and claystones.

The *Athyris* beds are standing nearly vertical or incline slightly to the N.N.E. for a few yards. Around the rocky headland the dip resumes its normal S.S.W. dip at very high angles, and from this point to the south side of Sandy Bay the dip is continuously in that direction, exposing a thickness of probably not less than 8,000 ft. of strata.

There are three zones of *Athyris* separated by beds of barren sandstone, the sequence in ascending order being as follows:—

1. Dark-blue indurated claystones.
2. Bed of granitic conglomerate, 4 in. thick.
3. *Athyris* bed, 40 in., richly fossiliferous.
4. Sandstone, 4 ft.
5. *Athyris* bed, 2 ft.
6. Sandstone, 4 ft.
7. *Athyris* bed, 18 in.
8. Indurated sandstones.

The upper *Athyris* bed (No. 7) is a coarse gritty, sometimes pebbly, sandstone containing shells of *Athyris* of at least two different species in such abundance that the rock is in places moderately calcareous. At this rocky headland the strata are nearly vertical, and, the overlaying thin layer of conglomerate and claystones having been worn down by

denudation, the lower fossiliferous *Athyris* bed (No. 3) stands up like the wall of a house, presenting an even surface 70 ft. high and 100 ft. long thickly incrusted with shells of *Athyris* which have weathered out of the matrix.

By far the greater proportion of the forms are impunctate *Athyris*, but the large *Spiriferina (Rastelligera)*, possessing fine comb-like dentition along the hinge-line, is not uncommon.

In the middle and upper fossiliferous zones *Athyris* are sparingly scattered in a sandstone matrix.

The *Athyris* beds form the natural close of the Trias formation. On stratigraphical and palæontological grounds they may be safely correlated with the *Athyris* beds forming the close of the Trias at the Wairoa Gorge and Eighty-eight Valley in Nelson, where the sequence of fossiliferous horizons shows a remarkable correspondence with that of Shaw Bay.

It is impossible in such widely separated districts to correlate bed with bed, but a comparison of the sequence clearly demonstrates a general harmony in the order of succession of the different zones.

In Eighty-eight Valley the sequence of the Trias, as indicated by the fossiliferous zones, is as follows :—

1. *Athyris* beds.
2. *Mytilus* beds.
3. *Trigonia* and *Spirigera* beds, with *Mytilus*.
4. *Halobia* and *Spiriferina* beds.
5. Plant beds.

The *Athyris* is a very unusual form, and is of great zonal value. It has been identified at the close of the Trias throughout New Zealand. Its distinctive characters are referred to in my paper on the Jurassic age of the Maitai formation, which appears in another part of this volume.

Monotis salinaria var. *richmondiana*, Zitt., which is so abundant in some parts of the Trias of Nelson and Southland, generally occurs in a horizon above the *Trigonia* beds.

In his report of 1873 Mr. McKay mentions that the upper conglomerate divides an *Ammonite* bed into two parts. The *Ammonite* bed is described as being "very rich in chambered shells of various genera"; but, unfortunately, we were unable to find any of the genera reported by McKay, and succeeded in discovering only one fragment of an ammonoid shell among the beach *débris*. Dr. Marshall, who visited this place with a party of his students in July, was more successful. He discovered a number of *Ammonites*, but they were all broken and fragmentary.

The great assemblage of sandstones, claystones, and slaty

shales which conformably follow the *Athyris* beds in the direction of Sandy Bay have been referred by Captain Hutton to the Mataura formation, and I have elsewhere shown that this formation is the equivalent of the Maitai rocks which overlie the Trias of Nelson conformably.

On the occasion of my visit to Nugget Point the coast-line was followed as far south as the south headland of Sandy Bay, and in that distance the dip was observed to be southwards at angles seldom under 75°.

Catlin's River District.

From the south head of Sandy Bay to the centre of False Island the dip of the beds is to the S.S.W. at varying high angles, which are not often under 70° or 75°. In this distance the thickness of strata exposed along the coast-line is probably not less than 13,000 ft.

At False Island the higher beds form a syncline, and proceeding southward from Catlin's Heads the same beds form a series of gently undulating anticlines and synclines, thereby preventing the exposure or repetition of the lower Triassic beds.

The beds consist of alternations of claystone, often shaly, sandstone, greywacke, and conglomerates.

Three distinct fossiliferous horizons were found between Cannibal Bay and Sandy Bay, all previously described by McKay.

In the first bay south of Sandy Bay, marked "Boat-landing Bay" on the survey map, McKay collected a number of fossils, but he did not mention any of the genera represented in his collection. In the same beds at Glenomaru quarry reserve, which is two miles inland, we collected, in indurated sandy claystones, a small species of *Ammonites*, *Pinna*, *Arca*, *Panopæa*, and *Pholodomya*.

This is apparently the lowest fossiliferous horizon of the Jurassic system, and it is of interest to note that it lies about 7,500 ft. above the *Athyris* bed at the top of the Trias in Shaw Bay. The intervening beds are principally claystones, grey sandstones, or greywacke devoid of organic remains, except a few scattered plant-remains.

In Tuck's Bay—that is the bay between Boat-landing Bay and Cannibal Bay—the rocks are principally sandstones, often coarse and pebbly. At the quarry reserve near the saddle overlooking Tuck's Bay we collected a number of *Inoceramus haasti*, *Inoceramus labiatus*, Schloth., and a small *Pecten*, which were found in the hard greenish-blue sandstone in which the road is excavated at that place.

This horizon is about 2,000 ft. above the lower *Ammonite* horizon.

From the quarry reserve southward the rocks are principally coarse sandstones, which extend almost to Cannibal Bay, when they are overlain by dark-blue indurated claystones, which strike between E. and E.N.E., and dip about S.S.W. at an angle of 82°. These claystones form the north side of Cannibal Bay. In them we found *Trigonia*, *Ostrea*, *Anomia*, *Inoceramus*, *Pholadomya*, and a *Venus*. Besides these, Mr. McKay reports the occurrence of *Ammonites* and *Belemnites* at this place, but they must be scarce, as we were unable to find any trace of them.

Between the north end of Cannibal Bay and False Island the rocks are obscured by sand. The lowest rocks on north end of False Island are conglomerates, followed by coarse pebbly sandstones, and these in turn by sandstones and claystones.

About the centre of the island the dip changes to the northward, whereby the sandstones and conglomerates are repeated on the south side of the island. The southern end of the island is traversed by a fault which repeats the conglomerate and brings into view some underlying sandstones. The thickness of the conglomerate is about 145 ft.

From the mouth of Catlin's River southward to Jack's Island the Cannibal Bay beds form the sea-cliffs, lying horizontal or occurring in gently undulating folds.

In the indurated dark-blue claystones at the north of Makura Bay were found *Ammonites novo-zealandicus*, Hauer, *Inoceramus haasti*, *Pholadomya*, a *Venus*, and a number of imperfect casts of conchiferous bivalves.

A number of indistinct bivalves occur in the sandstone cliffs opposite the south end of Jack's Island; and in the flat shelving rocks in Catlin's River, immediately opposite Pounawea Township, were found a considerable number of indistinct casts imbedded in a soft yellowish-brown sandstone.

The Trias of Nelson.

The Trias formation in Nelson is clearly exposed in three typical sections — namely, the section from Waimea Plains across Mount Heslington to the Wairoa Gorge; that from Wakefield to Sellen's run; and that along the course of Well's Creek, at Eighty-eight Valley, a few miles west of Wakefield. These sections are separated by intervals of a few miles, and as each crosses the same basin the sequence of rocks exposed in each is practically the same.

The clearest and most complete section is exposed in Well's Creek, where the sequence is as follows in descending order :—

0. *Clavigera (Athyris)* bed, calcareous pebbly sandstone.
1. Claystones.
2. Upper granite conglomerate.
3. *Mytilus* sandstone and claystone.
4. *Spirigera* sandstone.
5. *Mytilus* sandstone.
6. *Spirigera* and *Trigonia* sandstones.
7. Lower granite conglomerate.
8. *Halobia* claystones.
9. *Spiriferina* claystones and sandstones.
10. Plant beds, with *Tæniopteris*, *Asplenium*, &c.

The parallelism of the facies existing between the Nelson and Nugget Point sections is remarkable when we remember the distance which separates these places.

The details of the Nelson sections are given in my paper "On the Jurassic Age of the Maitai Formation," and need not be repeated here.

Mount Potts District, Upper Rangitata.

The Permo-trias and succeeding Jurassic rocks, extending from Mount Somers across the Harper Range westward to the Southern Alps, occur in a series of sharp folds. The core of the western anticlinal fold is well exposed in Tank Gully, a deep chasm excavated on the western flanks of Mount Potts, situated in the upper Rangitata. Here are seen the lowest beds of the Permo-trias, which consist of black carbonaceous slaty shales and sandstones containing a number of well-preserved plant-remains.

A collection of this fossil flora made by Sir Julius von Haast was submitted to the European palæobotanist Baron von Ettingshausen, who distinguished six different genera, of which the species were, he stated, mostly analogous to Triassic ones.*

The outcrop of the plant beds is very small, not much exceeding an acre in extent. It is situated in the higher part of Tank Gully, along the bottom of which it stretches for a distance of about 150 yards. The lower end of the outcrop is about 3,150 ft. above sea-level, and the upper part perhaps 200 ft. higher. The thickness of beds exposed is about 110 ft.

The plant beds are deeply involved in the core of a sharp anticline, and from their yielding character are much crushed and slickensided. They are surmounted by thousands of feet of sandstone and claystone, which along the axis of the anticline are also greatly bent and crushed.

Where the strata did not bend they have been subjected to lateral shearing stress, the effects of which can still be traced

* Trans. and Proc. N.Z. Inst., 1890, vol. xxiii., p. 241.

in some of the high precipitous rock-faces. A notable example is seen on the south-west side of Tank Gully, where the strata forming the summit of the ridge have been sheared along a nearly horizontal thrust-plane for some 17 ft., thus displacing them relatively to the strata below to that amount.

The strike of the beds on the north side of Tank Gully is N.E.–S.W., and the dip N.W. at very high angles, which are seldom under 80°. On the south side the strike is the same, and the dip S.E. at angles varying from 60° to 75°.

Mr. McKay, in 1877, examined this locality and noted the N.W. and N.E. dips, but he apparently failed to recognise the anticlinal arrangement of the beds.* In a section across Tank Gully he shows the dips correctly; but he marks the beds on the N.W. side of the anticline as Trias and those on the N.E. side as Carboniferous (Rimutaka series), and extends the latter in his sketch so as to pass unconformably below the former. It is noteworthy, however, that his description of the strata in Tank Gully does not correspond with his section.

The plant beds are succeeded by a series of greyish and greenish sandstones, slaty shales, and claystones. The shales and sandstones alternate both in thin laminæ and in thick beds. The greenish sandstones are generally highly indurated, and weather to a greyish colour on exposed surfaces. They are of all degrees of texture from fine-grained, which predominate, to coarse and gritty. They occasionally become pebbly, and pass into thin beds of sandstone conglomerate. In a few places the finer-grained sandstones are brecciated with small angular fragments of black claystone scattered sparingly through a thickness of a few feet.

The sandstones and claystones between Tank Gully and Rocky Gully are interbedded with a few beds of red slaty shale and a bed of pale-green aphanitic sandstone, which is often streaked with thin interlacing veins of white quartz.

Sir Julius von Haast, in 1861, examined the upper Rangitata,† and on that occasion discovered the fossiliferous beds in Rocky Gully. He subsequently revisited the same locality, in 1872,‡ and made a collection of marine shells and saurian bones, the latter including a number of vertebræ, one of which was referred by Sir James Hector to the genus *Ichthyosaurus*.§ At the same time a collection of plant-remains was made at Tank Gully.

In his collection from Rocky Gully Sir Julius von Haast reported the occurrence of *Orthis*, *Productus*, *Atrypa*, and

* Reps. Geol. Expl., 1877–78, p. 94.
† Von Haast, "Geology of Canterbury and Westland," 1878, p. 268.
‡ Reps. Geol. Expl., 1872–73, p. 1.
§ Trans. N.Z. Inst., vol. vi., p. 334.

Euomphalus, all Palæozoic genera, which led him to place his Mount Torlesse formation, of which these beds formed a part, in the Carboniferous period.* These genera have never been identified in other collections made at Rocky Gully, and we can only conclude that the forms to which these names were applied belonged to other genera.

The Rocky Gully marine beds are about 2,000 ft. higher in the series than the plant beds, being separated from the latter by the sandstones, shales, and claystones just described. The conformable relations of the Rocky Gully *Spiriferina* beds to Tank Gully plant beds seems to admit of little doubt, and is a point upon which Sir Julius von Haast and Mr. McKay were both agreed.

The fossils occur in indurated claystones and sandstones, which are interbedded with a pebbly bone bed varying from 2ft. to 4ft. thick. The bone bed contains a large number of broken shells and rolled fragments of bone. The sandstones, on each side of the bone bed, contain a few fossils, mostly *Brachiopoda*, scattered through a thickness of several feet.

A more varied assemblage of marine shells occurs in a bed of black claystone underlying the sandstone zone. This claystone has been subjected to great lateral thrust, with the result that the contained fossils are often flattened and distorted; while the stress has induced in the rock itself a tendency to break on exposed surfaces into long prismoidal pencils, an effect which adds considerably to the difficulty of securing perfect unbroken shells. In places the fossiliferous sandstones and claystones are slightly calcareous.

I collected from the lower horizon *Halobia*(?), *Megalodon*(?), *Nuculana*, *Athyris*, *Rhynchonella*, and *Spiriferina*, three sp.; and from the upper or bone-bed horizon *Orthoceras*, *Pleurotomaria*, *Turbo*, *Pentacrinus*, several bivalves not determined, and some fragments of saurian bones. Two small vertebræ were noted, but not collected, in a cavity in a large boulder. They were exposed in elevation so as to show the full size of the disc, which in the case of one was $\frac{3}{4}$ in. in diameter, and of the other $\frac{1}{16}$ in. less. They were flat or nearly so.

From Rocky Gully the section was followed up the Clyde Valley to the foot of Mount Goethe, on the main alpine divide, a distance of nine miles as the crow flies.

The rocks consist of a great succession of sandstones, greywacke, shales, and claystones. The sandstones are pale-grey, greenish-grey, and yellowish-green in colour, and vary in texture from fine-grained to coarse, gritty, and pebbly, in places passing into conglomerate. They are siliceous, and

* Reps. Geol. Expl., 1872–73, p. 6.

argillaceous, and frequently feldspathic, the latter passing into greywacke. They are mostly hard, being seldom soft, except where crushed, much jointed and shattered. Veins of quartz are common in the sandstones, especially in the yellowish-green variety.

The shales and claystones are present in endless variety, ranging in colour from pale-grey to yellowish-grey and green, from dark-green to black, and from chocolate-colour to red and purple. They are argillaceous and occasionally siliceous, but, like the sandstones, rarely calcareous. They are generally much jointed, and, when interlaminated with bands of the harder and more unyielding sandstone, are often crushed into a crumbling and drossy material presenting shining and slickensided surfaces, which led Sir Julius von Haast to describe them as "serpentinous." Some thin bands of slaty shale are silky in lustre and quite fissile.

These rocks dip at high angles in one continuous succession of beds to the north-west, thereby exposing between Mount Potts and Mount Goethe a thickness of not less than 40,000 ft. of strata.

The strike of the strata, from Rocky Gully to the junction of the Clyde and Lawrence Rivers, and thence up the Clyde for a mile and a half, is uniformly N.E.–S.W., and the dip N.W. The angle of dip varies from 65° to 70° at Rocky Gully to 83° at the river-junction, and in the Clyde for the first two miles from 85° to nearly vertical.

The strike, about a mile and a half above the junction, trends more towards the north, gradually bending from N.E. to N.N.E. until it is about N.–S. two miles above the Lawrence. From Maiden Flat Creek to Mount Goethe the strike is N.N.E.–S.S.W., and the dip W.N.W. at angles varying from 55° to 85°, the flatter angle being observed near Maiden Flat Creek.

The most careful search failed to discover organic remains in this magnificent pile of clastic rocks, excepting some obscure markings in the bands of black silky slate, which might be referred to annelid trails. No less remarkable than the absence of organic remains was the absence of limestones or calcareous beds, a circumstance commented upon by Sir Julius von Haast, who examined the same rocks in the Rakaia Valley and neighbourhood of Mount Cook.

The Jurassic and Triassic formations of New Zealand are everywhere connected in one continuous stratigraphical succession, and where the Upper Trias are fossiliferous, as at Nugget Point and Nelson, it is not difficult to establish a limit to the one and a beginning to the other. But in the Mount Potts section the Permian alone are fossiliferous, and it becomes a matter of difficulty to determine where the Trias

shall end and the Jurassic begin. And, after all, it is not a matter of very great importance whether we classify this great pile of strata as wholly Triassic or partly Triassic and partly Jurassic. The stratigraphical relations of the different beds must always remain the same wherever they are placed in the geological scale. On the other hand, the well-defined limitations of the Trias in Otago and Nelson leave little doubt that the Clyde River beds should be correlated with the Mataura and Maitai formations of Jurassic age.

Triassic Marine Rocks.

The position of the marine zones associated with the Triassic beds at Nelson, Hokonui Hills, and Nugget Point have now been accurately determined. The character and thickness of the sediments separating the zones were necessarily governed by the local conditions prevailing at the time of deposition, and therefore are found to vary greatly in the different basins; but the succession and relative position of the zones are always the same, clearly indicating that the different basins were connected by a continuous sea.

The zones contain a number of characteristic forms of fossils, and many of the species have been determined. Where the species have not been determined the genera of the *Brachiopoda* are often sufficiently distinctive for correlative purposes.

The prevalence of *Brachiopoda* in the lower and higher marine zones is conspicuous in all the Triassic basins throughout New Zealand.

Jurassic Marine Rocks.

The marine zones associated with the Jurassic beds of New Zealand are few in number and seldom rich in fossil forms. Characteristic fossils are rare, and the majority of the species have not yet been determined.

In his survey of the Hokonui Hills, in 1878, Mr. Cox subdivided the Jurassic rocks into four different groups or series of beds, but a subsequent examination which I made of his sections showed that his groups contained no characteristic marine zones, while in some cases they were found to overlap each other. Groups that cannot be identified in their typical localities are necessarily valueless for purposes of correlation.

The brachiopods which are so abundant in the Upper Trias in Nelson and Nugget Point basins are sparingly represented in the overlying marine zones of the Jurassic; and gasteropods are equally rare.

As late as 1899, Captain Hutton attempted no subdivision of the Jurassic rocks, and in the absence of sufficient data I

do not now propose to do so, but shall refer these rocks to my Mataura series, which is the same as Hutton's Mataura series of 1899.*

Hokonui System—Hutton† (Syn., Rangitata System—Park).

The vast assemblage of sedimentary strata just described comprises wholly, or in part, the Mount Torlesse formation of Von Haast. The rocks, unfortunately, in Mount Torlesse contain none of the fossiliferous horizons present in Nelson, upper Rangitata, or Nugget Point, with the exception of some indistinct plant-remains and a calcareous flattened tubular body which has been doubtfully referred to an annelid. In the absence of shell beds it is impossible to fix the position of the plant and annelid beds in relation to known horizons elsewhere. The Mount Torlesse plant beds may be contemporary with the Mount Potts plant beds, but in the absence of satisfactory evidence this correlation may be called in question at any time.

The Mount Torlesse formation, according to Von Haast, has a thickness of at least 25,000 ft.‡ It was placed by him up till 1865 in the Silurian period, but in 1878 he referred it to a time ranging from Palæozoic to Lower Mesozoic.§ The Carboniferous age of the lower beds was apparently based on the supposed identification of *Orthis*, *Productus*, and other Palæozoic genera in the Mount Potts *Spiriferina* beds at Rocky Gully.‖

The assemblage of strata exposed in the upper Rangitata attains a thickness not less than 40,000 ft. It possesses, too, well-marked fossiliferous groups of beds which are absent in the Mount Torlesse district. I am therefore reluctantly compelled to set aside Von Haast's formation-name, chiefly for the reason that the strata at Mount Torlesse do not afford the data necessary for their subdivision into groups and series of beds.

The main object of my investigations in the past three years has been to determine the succession and stratigraphical

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* Hutton, Trans. N.Z. Inst., 1899, vol. xxxii., p. 183.

† When I placed this paper before the Institute I included the Mataura, Shaw's Bay, and Kaihiku series in my Rangitata system. The name Rangitata seemed to me at that time to be more suitable than either the name Mount Torlesse or Hokonui; but on further consideration I have decided to adopt Captain Hutton's name Hokonui, using it in a somewhat more extended sense than originally intended by its author. The Hokonui system will now include all the rocks that are stratigraphically connected from the Permian to the Jurassic.

‡ Haast, "Geology of Canterbury and Westland," 1879, p. 279.

§ *L.c.*, p. 279.

‖ *L.c.*, p. 272.

relations of the Trias and associated rocks, and to establish a classification that shall be a safe standard for the correlation and grouping of strata throughout the colony belonging to the Lower Mesozoic and Upper Palæozoic periods. The nomenclature I have adopted is as follows:—

Hokonui system.

Jurassic ... 1. Mataura series.
Triassic ... 2. Shaw's Bay series.
(*a.*) *Clavigera* beds.
(*b.*) *Mytilus problematicus* and *Monotis salinaria* beds.
(*c.*) *Trigonia* beds.
(*d.*) *Halobia lommeli* beds.
(*e.*) *Spiriferina* beds.
(*f.*) Nugget Point plant beds.

This classification is an extension of that formulated by Captain Hutton in 1899, and a modification of that adopted by the Geological Survey in 1878.

The boundary between the Oreti and Kaihiku series of the Geological Survey is not very well defined, and in some places these series seem to cover the same set of beds. In other places, as in Nelson, the Wairoa series includes beds that are elsewhere included in the Oreti and Kaihiku series; and the *Clavigera* beds that in the Hokonui district constitute the Otapiri series have in Nelson been referred by the Geological Survey to the Kaihiku series.*

The Wairoa series, as defined by Sir James Hector in his "Outline of New Zealand Geology," 1886, pp. 72–74, apparently includes all the beds that are elsewhere considered to constitute the Oreti and Kaihiku series of the Geological Survey.

(f.) Nugget Point Plant Beds.—These are the lowest beds exposed at Nugget Point and Eighty-eight Valley, and they are correlated with the Mount Potts plant beds, which are also the lowest rocks exposed in the upper Rangitata. At the two former places they underlie the *Spiriferina (Psioidea)* beds; and at Mount Potts the Tank Gully plant beds appear to underlie the shell beds at Rocky Gully.

At Nugget Point the plant-remains are broken and indistinct; at Hunt's farm, in Eighty-eight Valley, they are broken, but distinguishable; while at Tank Gully the beds contain a varied and well-preserved flora. As I have just mentioned, the Tank Gully beds seem clearly enough to underlie the shell beds at Rocky Gully. They are readily accessible, easily found, and occur in such a position that their outcrop cannot be obscured or obliterated by cultivation or the con-

* Reps. Geol. Expl., 1878–79, p. 117.

structions of man. It was, moreover, from this place that Sir Julius von Haast obtained the collection of plant-remains sent to Europe for identification.

The place has therefore claims to be considered a typical locality, and, but for the doubt that still remains as to the age of the Mount Potts shell beds at Rocky Gully, I should have preferred to designate this group of beds the "Mount Potts plant beds," instead of "Nugget Point plant beds."

The Nugget Point beds form the long narrow promontory on which the lighthouse stands, and the outlying rocky islets. They are followed conformably by the *Spiriferina* beds. The dip of the beds is to seaward, and consequently the lowest beds of the series are not seen. The thickness exposed to view at low water is about 350 ft.

Sir James Hector identified among the plant-remains collected by Mr. McKay at Hunt's farm, in Eighty-eight Valley, *Glossopteris*, *Zamites*, and *Rhacophyllum*.*

Among the plant-remains from Tank Gully, Mount Potts, Baron Von Ettingshausen determined *Tæniopteris pseudovittata*, *Asplenium hochstetteri*, *Palissya podocarpiodes*, *Baiera australis*, and others, all more or less related to European Triassic forms.†

The form from Mount Potts identified by Sir James Hector as *Glossopteris* was determined by Ettingshausen to be *Tæniopteris*, and probably the Nelson *Glossopteris* also belongs to that genus.

(e.) Spiriferina *Beds*.—These embrace the lowest marine beds of the Hokonui system. Among the fossil shells found in them at Nelson, Nugget Point, and Hokonui Hills are *Spiriferina*, three sp., including the new sub-genus *Psioidea*,‡ created by Sir James Hector to embrace a small distinctive form resembling *Spiriferina cristata*, Schloth.; and *Epithyris*, *Rhynchonella*, and *Pleurotomaria*.

The long-winged species of *Spiriferina* found in these beds at Nugget Point, Hokonui, and Mount Potts have been referred by the Geological Survey to the genus *Trigonotreta* of König.§

(d.) Halobia lommeli *Beds*.—The principal forms in this horizon are *Halobia lommeli*, Wissm., *Nuculana*, *Retzia*, *Epithyris*, and *Psioidea*.

The evidence as to the age of the Mount Potts beds is, unfortunately, not very satisfactory; but the presence of *Halobia lommeli*, of bones supposed to belong to *Ichthyosaurus*, and the apparent absence of true *Spirifera* seem to correlate

* Hector, "Outline of New Zealand Geology," 1886, p. 74.
† Trans. N.Z. Inst., vol. xxiii., p. 237.
‡ Trans. N.Z. Inst., vol. xi., p. 537.
§ Hector, "Outline of New Zealand Geology," 1886, p. 75.

these beds with the *Halobia* and *Spiriferina* beds of Nelson, Nugget Point, and Southland.

Sir Julius von Haast collected from the Mount Potts beds in 1861 and in 1872, and in both his report of 1872* and "Geology of Canterbury and Westland," 1879, p. 272, enumerates the "following genera and probably species" which he says were identified by the late Professor McCoy: *Orthis spinigera, Spirifera lineata, S. lata, S. oviformis, S. duodecimocostata, Producta, Atrypa, Euomphala, Murchisonia, Orthoceras,* and *Encrinites,* forms which characterize the Carboniferous coalfields of New South Wales.

In 1877 Mr. McKay made a large collection of fossils at Rocky Gully,† but, curiously enough, his collection contained, he said, no *Orthis, Productus, Atrypa,* or *Euomphalus;* and Sir James Hector, in commenting on the age of the Mount Potts beds, says that Mr. McKay's collection contained no true *Spirifera,* the spirifer-like forms being all *Spiriferina.*‡

The fossils collected by myself at Rocky Gully in the early part of this year seemed to agree with the identifications of the Geological Survey rather than with those of Professor McCoy.

The saurian remains seem to make the matter no clearer. From the bone bed with the shell beds Von Haast collected a number of saurian bones, some of which he thought resembled "the vertebræ of ganocephalous reptiles of the Carboniferous period;§ as, for instance, those of *Denroerpeton, Hylonomus,* &c." Among these vertebræ Sir James Hector found one which he thought belonged to an *Ichthyosaurus,* which he named *I. australis.*‖

Sir Julius von Haast, however, subsequently challenged this identification, saying, "I fail to see any resemblance between the vertebræ and those of *Ichthyosaurus.*"¶

Mr. McKay, in his "Report relative to the Collection of Fossils from the Mount Potts Spirifer Beds," in 1878, says, "Among the additions contained in this new collection were portions of ribs and a vertebral centrum, evidently reptilian in character, which, closely resembling the vertebræ of *Ichthyosaurus* in general outline, was described as *I. australis* by Dr. Hector, who at the same time referred the beds to the Triassic period."**

Again in 1890, when discussing the relative age of the

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* Reps. Geol. Expl., 1872–73, p. 6.
† Reps. Geol. Expl., 1877–78, p. 94.
‡ Reps. Geol. Expl., 1885, p. xxvi.
§ Haast, "Geology of Canterbury and Westland," 1879, p. 272.
‖ Trans. N.Z. Inst., vol. vi., p. 334.
¶ Haast, "Geology of Canterbury and Westland," 1879, p. 272.
** Reps. Geol. Expl., 1877–78, p. 105.

Mount Potts and Clent Hills beds, the Director of the Geological Survey says, "The Mount Potts beds, besides an abundance of *Brachiopoda*, abound in reptilian remains, the true character of which has not yet been exactly determined, but from the nature of the vertebræ it would appear that these remains have some affinity to the genus *Ichthyosaurus*."* Then follow some details of the saurian remains found by Mr. McKay in 1877. The Director continues, "The vertebræ are much restricted in length, and the ribs flattened and hatchet-shaped, but not divided at the articulation. Some of the vertebræ are of enormous size, as much as 15 in. in diameter. One fine specimen not yet collected shows a convected series of sixteen vertebræ and thirty-two ribs of the character described. The centra of the vertebræ are 4½ in. in diameter, and the ribs are 3 ft. 6 in. in length."

The above conveys the impression that Sir James Hector entertained some doubts of his previous identification of *Ichthyosaurus*. In 1879 he so far modifies his opinion as to refer the remains to the genus *Eosaurus* of Marsh.†

So far as I could judge from the fragments of bone I saw and collected, I was of the opinion that at least two different genera of saurians were represented in the Rocky Gully bone bed.

The Mount Potts plant beds, which are acknowledged by Sir Julius von Haast and Mr. McKay to underlie the shell and bone beds at Rocky Gully, contain a flora which Ettingshausen described as being Triassic and Professor McCoy as Jurassic.‡

On the other hand, Professor McCoy is credited with having referred the exuvia of the shell beds, which appear to overlie the plant beds, to the Upper Devonian or Lower Carboniferous period.§

It should be mentioned, however, that Professor McCoy, in a memorandum to Sir James Hector dated the 12th August, 1885, distinctly denies that he had "heard of saurian bones mingled with Carboniferous shells in Mount Potts beds in New Zealand, and had not determined them." He admits, however, that he did make determinations of Carboniferous limestone *Mollusca* and *Echinodermata* submitted to him by Dr. Von Haast from Fossil Creek, Clyde, Rangitata, Southern Alps, and says that he has "no reason to doubt the age suggested for those beds as above."||

That a saurian-bone bed does occur at the close of the

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* Reps. Geol. Expl., 1890–91, p. 147.
† Reps. Geol. Expl., 1878–79, p. 11.
‡ Trans. N.Z. Inst., vol. xvii., p. 333.
§ *Loc. cit.*, p. 333.
|| Reps. Geol. Expl., 1885, p. xxi.

Rocky Gully fossiliferous shell beds is beyond all doubt, and, with respect to the diverse opinions and evidence quoted above, we can only conclude that a misunderstanding arose between Sir Julius von Haast and Professor McCoy in the transmission and description of the fossils.

Briefly, we find that the plant beds are held to be Triassic or Jurassic; while the overlying marine beds, on the shell determinations of Professor McCoy, are Carboniferous, or, according to the saurian determinations of Sir James Hector, Triassic.

(c.) Trigonia *Beds.*—In most places these are characterized by the presence of *Trigonia, Estheria minuta, Edmondia, Ammonites* (sp. not determined), a nautiloid shell, *Murchisonia, Conularia,* and *Spirigera (Athyris) wreyi,* Zittel.

These beds are well developed in Well's Creek, Eighty-Valley and Mount Heslington sections. In the Shaw's Bay eight Valley, and on southern slopes of Mount Heslington, Nelson, in Shaw Bay, and many parts of Hokonui Hills.

(d.) Mytilus problematicus *and* Monotis salinaria *Beds.*—These beds generally consist of a compact mass of *Mytilus* or *Monotis,* to the exclusion of all other forms.

The *Mytilus* beds attain a great thickness in Eighty-eight section the *Mytilus* bed is composed principally of a confused mass of oyster-shells. At Nelson the cast of a large *Gryphaea* is occasionally found in the *Mytilus* beds.

Monotis salinaria, Zittel, is present at Mount Heslington, French Pass, Okuku (in Canterbury), and many parts of Hokonuis. It is absent in the Shaw's Bay section. In the Hokonui sections *Monotis* seems to take the place of the *Mytilus,* so abundant in the Nelson Trias; and throughout that region the *Monotis* beds follow the *Trigonia* beds, as do the *Mytilus* beds in Nelson and southern Otago.

(a.) Clavigera *Beds.*—These beds everywhere form the close of the Trias. At Shaw's Bay they contain only two distinct shell-forms—namely, an *Athyris*-like form and *Spiriferina.*

The *Athyris* is rather an unusual form. It is smooth, bisulcate, has a long slightly curved hinge-line, and possesses the habit of a spirifer rather than that of an *Athyris.* It corresponds closely with the *Clavigera* of Hector, which is a subgenus of *Athyris* created to include this unusual form.*

The *Spiriferina* possesses a straight hinge-line with comb-like dentition, and is the sub-genus *Rastelligera* of Hector.†

In Well's Creek, Nelson, the *Athyris* horizon contains several species of *Spiriferina* (including *Rastelligera,* which is

* Trans. N.Z. Inst., vol. xi., 1878, p. 537.
† *Loc. cit.*, p. 537.

always a characteristic form), *Athyris* (*Clavigera* of Hector), *Patella*, *Pentacrinus*, fragments of saurian bones, and corals.

The *Clavigera* beds correspond approximately with the Otapiri series of the Geological Survey.

Contemporary Eruptive Rocks.

At Nugget Point a dyke of augite porphyrite is intruded between the *Spiriferina* and *Halobia* beds. It has already been referred to in that portion of my paper dealing with Nugget Point district. Elsewhere the Shaw's Bay series seems to be free from igneous intrusions, although it should be noted that in north Otago and upper Rangitata they contain massive beds of greywacke.

Nomenclature.

The name "Shaw's Bay series" was first applied to the Trias of Nelson and Southland by Dr. Lauder Lindsay as far back as 1857. Afterwards, in 1873, Sir James Hector set Lindsay's name aside, substituting the name "Wairoa series," which at that time embraced the whole of the Trias.* Subsequently, in 1877, the name "Wairoa series" was restricted to the Upper Trias, as follows:—†

Trias { (*a.*) Wairoa series.
(*b.*) Te Anau series.

In this sense the name was used up till 1878, when Mr. Cox subdivided the Trias into "Upper Wairoa series" and "Lower Wairoa series," which together now embraced the whole of the Trias. In this new classification, however, the *Clavigera* (Otapiri) beds were referred to the Lias and the Kaihiku beds to the Permo-carboniferous.‡

In the Geological Survey classification of 1879 the Wairoa series is placed in the Middle Trias, with the Otapiri series above and the Oreti series below, as follows:— §

"X.—Trias.
"(*a.*) Otapiri series.
"(*b.*) Wairoa series.
"(*c.*) Oreti series."

In the classification of 1880 the Wairoa series appears in the Lower Trias,‖ and in that of 1884 again in the Middle Trias, between the Otapiri and Oreti series.¶ In the last

* Reps. Geol. Expl., 1876–77, p. v.
† *Loc. cit.*, p. v.
‡ Reps. Geol. Expl., 1877–78, p. 37.
§ Reps. Geol. Expl., 1878–79, p. 10.
‖ Reps. Geol. Expl., 1879–80, p. iv.
¶ Reps. Geol. Expl., 1883–84, p. xiv.

classification of the Geological Survey Sir James Hector once again referred it to the Lower Trias.*

Captain Hutton, in his latest classification of New Zealand formations, includes the whole of the Trias and Permian rocks of the Geological Survey in his Wairoa series, which is thus the equivalent of the Shaw's Bay series of Lindsay.

The Wairoa series of Captain Hutton has a very different meaning to the present Wairoa series of the Geological Survey, and therefore to avoid the confusion that might arise from the use of that name I have thought it advisable to discard it for Lindsay's original name, "Shaw's Bay series," which not only possesses the right of priority, but can claim to take its name from a place where the development of the Trias is as perfect as anywhere in New Zealand, and free from faulting, folding, and tectonic disturbance that might lead to doubtful interpretations of the succession and relations of the different marine horizons.

AGE.

The marine beds at the base of the Nugget Point section, embracing the *Spiriferina* beds (the *Productus* formation of McKay), have since 1878 been referred by the Geological Survey to the Permian Kaihiku series, but no stratigraphical or palæontological evidence has been adduced to support this view. On the contrary, it has been shown that the Kaihiku series always forms a part of the Triassic succession of strata; and Sir James Hector, when discussing the age of the Kaihiku series, says, "The occurrence of these saurian remains" [*Eosaurus* of March], "together with the survival of many Permian forms into the Wairoa, and even the Otapiri, series, and the absence of true spirifers, *Productus*, and other usual Palæozoic elements of a Permian fauna, would seem to connect the Kaihiku series rather with the Mesozoic than the Palæozoic formations of New Zealand."†

In Nelson, Otago, and Southland the *Spiriferina* beds are followed by the *Halobia (Daonella) lommeli* beds, and in the European alpine Trias this is one of the distinctive forms of the lowest division of the Upper Trias.

In 1869 Mojsisovics arranged the Trias of North and South Tyrol Alps so as to place the nodular limestone with *Halobia lommeli* at the base of his Noric division, but we have it on the authority of Zittel that the stratigraphical researches of Hauer, Richthofen, and Gümbel had shown that this arrangement arose from a series of stratigraphical blunders on the part of Mojsisovics.

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* Reps. Geol. Expl., 1890–91, p. 121.

† Reps. Geol. Expl., 1878–79, pp. 11 and 12.

So far as I can discover, there is no authentic record of *Halobia lommeli* from the Lower Trias of Europe, and, if we assume that a homotaxial parallelism existed between the Trias of the Pacific and Europe, it is evident that the *Halobia* beds of New Zealand must be referred to the lower part of the Middle Trias.

I have shown in a paper "On the Jurassic Age of the Maitai Series" that the *Clavigera (Athyris)* beds in Well's Creek, referred in 1879 by Mr. McKay to the Permian, were the closing beds of the Trias, and occupied the same position as the *Clavigera* beds at Shaw's Bay and Otapiri.

The theory of inversion of the whole Triassic system in Nelson, by means of which Mr. McKay sought to establish the inferior position of the Maitai series, brought many difficulties with it, and rendered it impossible to correlate the Nelson marine horizons with the succession so clearly established in Southland and southern Otago.

The many attempts to reconcile the inverted succession in Nelson with the normal succession elsewhere were unsatisfactory even to the Geological Survey, judging from the frequent rearrangement of the groups subsequent to 1878; and, naturally, the blending of the two resulted only in confusion.

The persistence of *Clavigera*, *Rastelligera*, and other brachiopods possessing an Upper Palæozoic facies right up to the base of the Jurassic must always impress the New Zealand Trias with Palæozoic affinities, and tend to correlate it with the Alpine Trias of Europe rather than the beds of the great German Triassic basin. Palæontology will doubtless provide general systematic types, which will assist arrangement into smaller divisions, and afford a safe basis for correlations with distant lands.

Mataura Series.

(Syn., *Mataura Series*, Lindsay, Hector, and Hutton; *Putataka Formation*, Hutton; *Mataura, Putataka, Flag Hill*, and *Bastion Series*, Cox; and *Catlin's River*, Hector.)

The Putataka formation of Hutton included this formation and a portion of the Shaw's Bay formation, and also the original Mataura series of Lindsay and Hector. The Mataura series of the latter was, in 1878, subdivided by the Geological Survey into five series, as follows :—*

Jurassic { (*a.*) Mataura series. (*b.*) Putataka series. (*c.*) Flag Hill series.

Liassic { (*a.*) Catlin's River series (Hector). (*b.*) Bastion series.

* Rep². Geol. Surv., 1877–78, p. vii.

The Catlin's River series of Hector was interpolated in Cox's classification, being placed sometimes above and sometimes below the Bastion series.

In my revision of the classification adopted by Cox in 1878 for the formations in Southland, I showed that the Mataura series and Flag Hill series referred to the same group of beds,* and, after an examination of Catlin's district, I am of the opinion that the beds included in the Catlin's River series of Hector will be found to belong to the Mataura series of Cox's classification.

The beds included in the Mataura series from the south headland of Shaw Bay to False Island exhibit a thickness of not less than 13,000 ft. In the upper Rangitata their thickness probably exceeds 30,000 ft. In these localities they are devoid of all trace of organic remains, excepting doubtful worm-trails in the Clyde Valley beds, and indistinct plant-remains and three thin marine zones between Sandy Bay and Cannibal Bay. The lithological character of the beds tends to show that they were of estuarine origin. The most characteristic genus in the Cannibal Bay beds is *Inoceramus*, which occurs in the two highest zones.

The beds grouped in this series in Nelson contain an *Inoceramus* zone about 100 ft. above the Triassic limestone, also a band of fissile slaty shale crowded with supposed worm-trails. The total thickness of the strata exposed on the flanks of Dun Mountain is about 25,000 ft.

In the Geological Survey classification the strata included in the Mataura series are subdivided, as we have seen, into five different groups or series. Three, and probably more, of these series overlap each other, and until more definite information is available I think it would be unwise to perpetuate a multiplication of place-names that at present have no meaning, and are useless for purposes of correlation.

Relationship to Underlying Strata.

In 1886 I showed that the Mataura series and Flag Hill series of Cox referred to the same group of beds.† At the same time I showed that the Mataura plant beds at Mataura Falls followed the Upper Trias granite-conglomerate (2 ft.) and sandstones of Ship Cove conformably, and were underlain by a marine horizon containing *Belemnites*, *Ostrea*, *Pecten*, *Pholadomya*, &c. In dark-blue slaty shales overlying the shell bed I found what I then identified as *Pecopteris grandis*, probably the *Pecopteris proxima* of Ettinghausen; *Asplenites*, probably *Asplenium hochstetteri*, Ettings.; two species of *Tæniopteris*,

* Reps. Geol. Expl., 1886–87, p. 146.
† *Loc. cit.*, p. 146.

probably *T. pseudo-simplex* and *T. lomariopsis*, Ettings.; and a species of *Taxites*.*

The conformable relation of the Mataura Falls beds to the Trias is clearly seen in the section from Mataura to Gore.

The conformable relations of the Mataura series (syn., Matai series) of Sandy Bay and Catlin's beds to the Trias of Nugget Point have already been described.

Age of Mataura Series.

Baron Von Ettingshausen, who examined a collection of plants from the Mataura Falls beds, stated that "the species bear more or less the facies of those of the Triassic flora,"† a conclusion quite in harmony with the stratigraphical evidence, which shows that the plant beds follow the Upper Trias. The boundary between the two formations is quite arbitrary, and might easily be fixed so as to place the plant beds in the Trias.

On the other hand, the presence of *Inoceramus*, *Belemnites*, and *Ammonites* in the Mataura beds, and *Inoceramus* in the Maitai and Dun Mountain beds, clearly establishes a relationship to the Jurassic rather than to the Triassic period.

No attempt has been made to subdivide the Jurassic and Trias rocks into minute groups of beds. This is a work that can only be successfully accomplished when the fossils have been determined by a palæontologist. Minute subdivision which is not supported by accurate detail and clear definition is certain to be abandoned, and this has been the history of many attempts at subdivision in New Zealand where the facts were not sufficiently ascertained or supported by accurate data.

To avoid confusion in the literature of the subject I have discarded many of the old names, some of which were used by different authors with different meanings. The local names adopted by me refer to places where the rocks thus designated are typically developed, and where their relationship to the associated formations is clearly defined.

Distribution of Mataura Series.

In my paper on the Jurassic age of the Maitai series I showed that the rocks of that series, as typically developed in Nelson, overlaid the Trias conformably, and contained the Secondary genus *Inoceramus* in abundance. On these grounds I contended that the Maitai rocks could not be Carboniferous, but must be subsequent to the Trias; and I therefore referred them back to the Jurassic period, where they were originally placed by Captain Hutton in 1875. The evidence seems conclusive that the Maitai and Mataura rocks are contem-

* Reps. Geol. Expl., 1886–87, p. 146.
† Trans. N.Z. Inst., vol. xxiii., p. 42.

porary formations, and must therefore be grouped together under one name, which for reasons already specified must preferably be the place-name Mataura.

It is probable that all the rocks hitherto referred to the Carboniferous by the Geological Survey are Jurassic or Juro-triassic, with perhaps the exception of the gold-bearing rocks at Reefton, concerning the age of which no definite information is available, and certain aphanitic sandstones, breccias, and slates in the mountains west and north of Lake Wakatipu.

The Jurassic Mataura series, now comprising the Maitai series, has a wide distribution in both Islands, and is in most places so intimately associated with the Trias in the formation of the great tectonic features of our mountain-chains that the limits of the Trias may broadly be said to define the distribution of the Jurassic.

In Southland the Mataura series occupies a wide tract of country, which extends south of a line drawn from the Mataura Falls to the south head of Roaring Bay, near Nugget Point. Again, passing northward into Canterbury, the enormous thickness and disposition of the Jurassic rocks in the upper Rangitata seems to justify the conclusion of Von Haast, expressed in 1873, that the great mass of the Canterbury Alps, extending from Mount Cook to the sources of the Rakaia, was composed of rocks of Jurassic age.

In some parts of Nelson, and more particularly in the vicinity of Dun Mountain range, the limits of the Jurassic and Triassic rocks are fairly well defined; but elsewhere in Nelson, and in the North Island generally, it is impossible with our present information to define the respective limits of the two systems, excepting in a few isolated patches, as at Kawhia, Raglan, and Waikato Heads.

The Mataura series is the important member of the great Hokonui system of Juro-permian age.

General Distribution of Hokonui System.

This vast assemblage of sedimentary strata comprises a stratigraphical system ranging in time from Permian to Jurassic in one unbroken succession. It is the principal mountain-builder in New Zealand, and in its vastness, in the character of its sediments, age, and tectonic importance, bears a marked resemblance to the celebrated Gondwána system in India. Its nearest equivalent is the great Juro-permian system of New Guinea.

In the North Island of New Zealand it forms the Tararua, Rimutaka, Ruahine, and Kaimanawa Mountains, extending in one almost unbroken chain from East Cape to Cook Strait. Outlying patches occur at Coromandel, Tuhua, Kawhia, Waikato Heads, and north of Auckland.

From the French Pass it stretches to Nelson, where it forms all the massive mountains lying between Golden Bay and Marlborough. It occupies the Kaikoura, St. Arnaud, and Spencer Mountains; and thence, spreading southward, forms the greater part of the Southern Alps, as well as the great subsidiary ranges that descend eastward toward the Canterbury Plains. From South Canterbury rocks belonging to this system cross into North Otago, whence they stretch westward to the main divide. In Southland they occupy the greater part of the land-surface, and sweep round the south end of Otago to Nugget Point and lower Clutha.

[Note.—Since the above was written collections of fossils from the Trias in Nelson and Permian at Mount Potts, made by me early in the year, have been sent to Professor G. Boehm of Freiburg University for determination, to whom also were sent at the same time collections of shells from the Jurassic and Triassic rocks at Nugget Point and Catlin's River made by Mr. A. Hamilton and myself.—The Author.]

REFERENCE TO PLATES XXVIII.-XXXI.

Plate XXVIII.—Geological Sketch-plan and Section of Coast-line between Nugget Point and Catlin's River.

Plate XXIX.—Section from South Head, Shaw's Bay, to Nugget Point.

1. Claystones and sandstones.
2. *Athyris* sandstones.
3. Coarse sandstones.
4. Oyster and *Mytilus* bed.
5. Banded claystones and sandstones.
6. *Trigonia* beds.
7. Granite conglomerate.
8. Sandstones with claystone bands.
9. Breccia conglomerate.
10. Claystones and sandstones.
11. Greywacke.
12. Indurated claystones.
13. Breccia conglomerate.
14. Claystones and sandstones.
15. *Halobia* claystone.
16. Dyke of porphyrite.
17. Greywacke.
18. Black *Spiriferina* claystones.
19. Claystone plant beds.

A. Track to Roaring Bay.
B. Nugget Point Lighthouse.

Plate XXX.—Section from Mount Cook Range to Potts River.

Jurassic
1. Sandstones with beds of claystone.
2. Sandstones, greywacke, and slaty claystone.
3. Sandstones and slaty shales.

Triassic
4. Fossiliferous claystones and conglomerate.
5. Tank Gully plant beds.

2*a*. *Inoceramus*, *Pentacrinus*.

Plate XXXI.

Upper Figure.—Section on South Side of Tank Gully.

(*a*.) Thin-bedded shales and sandstones.
(*b*.) Grey sandstones.

Lower Figure.—Section across Tank Gully.

(*a*.) Sandstones.
(*b*.) Black Carbonaceous shales with fossil fern-leaves.

Art. XXXI.—*On the Age and Relations of the New Zealand Coalfields.*

By Professor James Park, F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 3rd December, 1903.*]

The geology of the coalfields is a subject of great industrial importance, and for this reason is generally the first problem to engage the attention of the geologist in a new country. Moreover, it is obvious that no reliable advice can be given by any one as to the search for coal until the coal-bearing formations have been determined, and the relations and distinctive features of the different members of each ascertained by careful investigation in the field. At the present time there is no general agreement as to the age of the coalfields of New Zealand, excluding from our present consideration the thin seams of bituminous coal found at Otapiri, Wyndham, and Waikawa, in Southland, and on the West Coast south of Waikato, in the North Island, which are acknowledged to be Jurassic; also the lignites of Kaipara, Manukau Harbour, central Otago, and Southland, which are believed to be Pliocene or later.

The valuable coalfields of Auckland, Mokau, west coast of South Island, Canterbury, and Otago are held by the Geological Survey to be of one age, and to belong to the Cretaceo-tertiary period. The late Ferdinand von Hochstetter,* Sir Julius von Haast,† and Captain Hutton have maintained that there are two or more coal-bearing formations in New Zealand.

Captain Hutton, in a paper "On the Relative Ages of the New Zealand Coalfields," gives an able summary of the views held by himself and the Geological Survey.‡ He discusses the correlation of the Amuri limestone and hydraulic limestone of north Auckland, and, after reviewing the evidence bearing on the stratigraphical position of the latter and its relation to the Oamaru series, arrives at the conclusion that the correlation cannot be sustained. And it seems to me he could form no other conclusion from the conflicting evidence presented to him. In the Geological Survey Reports the hydraulic limestone is generally stated to overlie the Whangarei limestone, the supposed equivalent of the Oamaru stone, whereas the Amuri limestone always underlies that

* "Geology of New Zealand," 1867, pp. 58 and 59.

† "On the Character and Age of the New Zealand Coalfields," Rep. Brit. Assoc., 1886, p. 643.

‡ Trans. N.Z. Inst., 1889, vol. xxii., p. 377.

horizon in North Canterbury and elsewhere. As the Amuri limestone could not both underlie and overlie the same formation, Captain Hutton naturally concluded that the hydraulic limestone had no connection with the Amuri limestone of the South Island.

In 1899 I revisited the north Auckland coalfields, and, after a careful re-examination of the old sections and many new, formed the opinion that the Geological Survey was right in correlating the hydraulic limestone with the Amuri limestone, but wrong in placing the hydraulic limestone above the Whangarei limestone.

In 1874 Sir James Hector placed the "grey and chalk marls" [hydraulic limestone] of the Kaipara district at the top of the Cretaceo-tertiary series, in which he also included the underlying greensands and *Inoceramus* clays, in the following order:—*

Cretaceo-tertiary
4. Grey and chalk marls.
5. Greensands and coal grits.
6. *Inoceramus* clays, &c.

Mr. Cox, in his report on the Kaipara district in 1880, also refers the hydraulic limestone and underlying glauconitic greensands to the Cretaceo-tertiary period.† He discusses the stratigraphical position of the hydraulic limestone, and, when speaking of the large boulders incrusted with cone-in-cone limestone at Batley, says, on page 21, "If these cone-in cone beds are interstratified with the chalk marls and hydraulic limestones, as they appear to be, it would give a certain amount of evidence in favour of the whole series being older than I have considered it"—that is, than Cretaceo-tertiary. On page 19 he gives a section near Captain Colbeck's, at Pahi, in which the Whangarei limestone and what he calls "Miocene greensands" are shown lying unconformably on the hydraulic limestone.

Mr. McKay, in 1883, in his report "On the Geology of the Coal-bearing Area between Whangarei and Hokianga,"‡ places the Amuri [hydraulic] limestone and chalk marls below the Ototara and Weka Pass stone [Oamaru stone], and it is noteworthy that, while Mr. Cox shows the Whangarei limestone at Colbeck's resting in a narrow gutter excavated in the hydraulic limestone, Mr. McKay states that the hydraulic limestone is underlain conformably by the Whangarei limestone (page 115), which obviously, according to this view, could not be the equivalent of the Oamaru stone.

In his report on Waitemata and Rodney Counties§ in the

* Reps. Geol. Expl., 1874, p. vi.
† Reps. Geol. Expl., 1879–80, p. 18.
‡ Reps. Geol. Expl., 1883–84, p. 113.
§ *Loc. cit.*, p. 106.

same year Mr. McKay shows that the upper Waitemata beds rest unconformably on the hydraulic limestone at Mahurangi, in this agreeing with the opinion expressed by Mr. Cox in 1880 (Geol. Reps., 1879–80, p. 29). At the end of his report Mr. McKay gives a tabulated statement of the strata passed through in four boreholes put down in that year by the Kawakawa Coal-mining Company in the search for coal, according to which borehole No. 2 is supposed to have passed through 234 ft. 2 in. of what is termed "Amuri limestone, chalk marls, and chalk with flints, VI.*d*."

In my report on the Kaipara district in 1885 I included the hydraulic limestone in the Cretaceo-tertiary series, and placed it above the Pahi greensands, from which I made a large collection of marine shells having a facies closely resembling the fauna of the Waihao greensands in South Canterbury.* On this occasion I distinguished two horizons of greensand—namely, coal greensands, containing the Tertiary fauna just referred to, and glauconitic greensands (page 169), which I said appeared to occur at the base of the Cretaceo-tertiary series, and were interbedded with a cone-in-cone limestone and a calcareous sandstone, in which I found remains of *Inoceramus*. In this report I described how the Komiti beds (Mount Brown series) lay unconformably on the chalky marls and hydraulic limestone.

In my report on the Kaipara district in 1887† I again described the hydraulic limestone as overlying the coal greensands, but underlying the Whangarei limestone; but when discussing the relations of the hydraulic limestone to the associated beds I stated that "the relation of the hydraulic limestone and underlying marly greensands is not so satisfactory as might be desired" (p. 229).

Mr. McKay, in 1888, examined the Pahi and Paparoa sections, and, while agreeing with me that the hydraulic limestone overlies the coal, continues as follows: "Mr. Park believes that in the sections at Paparoa and Pahi there is an unconformity between the beds with *Inoceramus* and the white clays under the Whangarei limestone, . . . but I must say I could not convince myself of the existence of such unconformity."‡

Mr. McKay still places the hydraulic limestone above the Whangarei limestone,§ but is apparently doubtful of this, as on page 54 he says, "The lower beds, supposed" [by the author] "to be unconformable, are well developed between

* Reps. Geol. Expl., 1885, p. 168.
† Reps. Geol. Expl., 1886–87, p. 222.
‡ Reps. Geol. Expl., 1887–88, p. 54.
§ *Loc. cit.*, p. 43.

Maungaturoto and Colbeck's estate, and appear in that direction perfectly conformable to the hydraulic limestone; and all over the west of the Bay of Islands County and in the Hokianga district I judged the relations of the hydraulic limestone to the *Inoceramus* beds to be a relationship showing the stratigraphical conformity of the higher and lower beds mentioned."

Mr. McKay, in 1890, in his report "On the Prospects of Coal at Pakaraka, Bay of Islands, Auckland," again affirms his belief that the hydraulic limestone overlies the Whangarei limestone. Speaking of the section at Ngahikunga, he says, "The limestone" [Whangarei] "is overlain by the firestone and hydraulic limestone division of the Cretaceo-tertiary series."*

In the same year Mr. McKay, reporting on the geology of the district around Whangaroa Harbour, states that in the north branch of the Kaeo River the hydraulic limestone forms "the highest member of the" [Cretaceo-tertiary] "series,"† and is, he continues, overlain, apparently conformably, by the Kaeo greensands, that had always been regarded by the Geological Survey as the equivalent of the Kawakawa greensands forming the roof of the coal. As the hydraulic limestone was still supposed to overlie the coal greensands, the Kaeo greensands, since they followed the hydraulic limestone, were now correlated with a horizon in harmony with that theory.

In 1892 Sir James Hector illustrates his Progress Report with vertical sections of the boreholes put down by the Kawakawa Coal Company in 1883, and shows, as did Mr. McKay, the "Amuri limestone, chalk, chalk with flints, VI.*d*," overlying the Whangarei limestone.‡

Mr. McKay, in his report "On the Hikurangi Coalfield" in 1892, shows the hydraulic limestone as the closing member of the Cretaceo-tertiary series, and, as in former reports, it is shown overlying the Whangarei limestone conformably.§

The succession of beds on the south side of Parengarenga Harbour, in the North Cape district, is stated by Mr. McKay to be, in descending order — hydraulic limestone, firestones interbedded with greensand, shales and sandstone with calcareous concretions, often covered with a layer of cone-in-cone limestone, and containing fragments of *Inoceramus*.‖ This section, it will be seen, is almost identical with that at Batley, on the Kaipara.

Sir James Hector, in his Progress Report for 1903,

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* Reps. Geol. Expl., 1890–91, p. 62.
† *Loc. cit.*, pp. 68 and 69.
‡ Reps. Geol. Expl., 1892–93, p. xii.
§ *Loc. cit.*, p. 57.
‖ *Loc. cit.*, p. 86.

page xii., commenting on Mr. McKay's work in the North Cape district, uses the following significant words. He says, "No fossils have yet been found in this stratum" [hydraulic limestones] "where it overlies the formations next to be mentioned" [*i.e.*, Whangarei limestone and coal greensands] "in the Kawakawa Basin by which their age can be decided. They" [hydraulic limestones] "have been referred to the horizon of the Amuri limestone. If they are the same limestone as that mentioned by Mr. McKay as occurring at the sources of the Waitangi and Kaeo Rivers, and which is associated stratigraphically with sandstones and shale containing *Ammonites* and *Inoceramus*, this identification would be justified. Unfortunately, wherever these forms are found the downward sequence does not develop the greensands with coal as at Kawakawa. On the contrary, greensands decomposing to rusty sands, and containing such forms as characterize the cover of the coal at Kawakawa and Hikurangi, and also on the west coast of the South Island, are reported by Mr. McKay to rest on the hydraulic limestone of the Kaeo locality."

Reviewing the foregoing, we find that Sir James Hector, Mr. Cox, and Mr. McKay have always maintained (*a*) that the hydraulic limestone overlies the Whangarei limestone which was acknowledged to overlie the coal-measures of Kawakawa and Hikurangi; (*b*) that the hydraulic limestone was the equivalent of the Amuri limestone in the South Island; and (*c*) that the Pahi and Kawakawa coal greensands containing a Tertiary fauna were the equivalent of the greensands with *Inoceramus* underlying the hydraulic limestone.

The Amuri limestone is held by the Geological Survey to underlie the Oamaru (Weka Pass) stone conformably; therefore with the hydraulic limestone above the Whangarei limestone, and its equivalent the Amuri limestone below the Oamaru stone, it was found impossible to correlate the Whangarei limestone with the Oamaru stone.

The views expressed by myself were (*a*) that the hydraulic limestone underlaid the Whangarei limestone, (*b*) that the latter was the equivalent of the Oamaru stone, (*c*) that the hydraulic limestone was the equivalent of the Amuri limestone, and (*d*) that the hydraulic limestone overlaid the coal greensands.

It should be noted, however, that every one, myself included, expressed some doubt as to the true relations of the hydraulic limestone; and it may be mentioned that the many discordant views on this important question were principally due to the obscurity of the sections, caused by the disturbed condition of the strata and the difficulty of obtaining a continuous or complete succession of the beds on account of the

land being deeply intersected by numerous tidal rivers and ramifying arms of the sea.

The evidence of the Kawakawa boreholes, supplied by Mr. McKay, seemed perfectly conclusive that the hydraulic limestone was superior to the coal-measures; but I found, on making inquiries from Mr. T. P. Moody, under whose supervision the boreholes were put down, that no hydraulic limestone was actually cut in the boreholes. The beds in No. 2 borehole, referred by Mr. McKay to the Amuri-limestone group of the Cretaceo-tertiary, were as follows:—

	Ft.	in.
Blue clay	30	0
Chocolate-coloured clay ...	10	0
Soft clays, no core	194	2
	234	2

It is obvious from the above that Mr. McKay did not base his opinion regarding the superior position of the hydraulic limestone upon the identification of that rock in the material cut in the borehole, but correlated the above clays with the Amuri limestone, apparently because these clays occupied the position relatively to the Whangarei limestone which the hydraulic limestone was supposed to occupy.*

After an exhaustive inquiry in 1899 as to the position of the hydraulic limestone, I found (*a*) that the hydraulic limestone is conformable to the glauconitic greensands and cone-in-cone beds at Batley and elsewhere, and belongs to the same stratigraphical system; (*b*) that the Geological Survey was right in correlating the hydraulic limestone with the Amuri limestone, but (*c*) was wrong in placing the hydraulic limestone above the Whangarei limestone; (*d*) that I was right in correlating the Whangarei limestone with the Oamaru stone; (*e*) that I was right in placing the hydraulic limestone below the Whangarei limestone, (*f*) but wrong in identifying the white clays interstratified with shelly limestone in the Pahi section with the hydraulic limestone; (*g*) that the greensands at Pahi containing a Tertiary fauna occur at the base of the Lower Tertiary series, and are probably the equivalent of the greensands forming the roof of the coal at Kawakawa and Hikurangi; and (*h*) that the Komiti beds, referred by me doubtfully to the Pareora series, probably form the lowest horizon of the Lower Tertiary series—or, in other words, that the Komiti beds form the lower beds of the Pahi greensand series.

The stratigraphical connection of the hydraulic limestone to the *Inoceramus* greensands was practically admitted by

* Reps. Geol. Expl., 1883–84, p. 133.

Mr. McKay in 1887 when he wrote, "And all over the west of the Bay of Islands County and in the Hokianga district I judged the relations of the hydraulic limestone to the *Inoceramus* beds to be a relationship showing the stratigraphical conformity of the higher and lower beds mentioned."*

The succession of formations determined by me in 1899 was as follows, in descending order :—

Miocene : Komiti beds, Pareora series(?)—
- (*a.*) Foraminiferal limestone.
- (*b.*) Volcanic tuffs, with lignite.
- (*c.*) Volcanic breccias.
- (*d.*) Ferruginous sandstones.
- (*e.*) *Crassatella* beds.
- (*f.*) Sandy clays, with *Pecten zittelli.*

Oligocene : Oamaru series—
- (*a.*) Whangarei limestones.
- (*b.*) Calcareous sandstones.
- (*d.*) Marly greensands, with Tertiary marine fauna.
- (*e.*) Coal-seams and fireclay.
- (*f.*) Grits and conglomerates.

Cretaceous : Waipara series—
- (*a.*) Grey chalky claystones.
- (*b.*) Hydraulic limestone.
- (*c.*) Glauconitic greensands.
- (*d.*) Calcareous flaky sandstone and shaly clays, with *Septaria* often incrusted with a layer of cone-in-cone limestone.

Trias—
- Slaty shales and sandstones forming basement rock of country.

It is not a little singular that in places outside the North Auckland district the stratigraphical connection of the hydraulic limestone and *Inoceramus* shaly clays with cone-in-cone limestone has never been called in question.

In his first report on East Cape district† Mr. McKay considers them conformable; and in his reports "On the Country between Cape Kidnappers and Cape Turnagain,"‡ and "On the Southern Part of the East Wairarapa District,"§ they are shown to belong to the same series, and are placed in the younger Secondary period.

A re-examination of the country north of Napier in 1886 did not lead Mr. McKay to change his opinion on this

* Reps. Geol. Expl., 1887–88, p. 54.
† Reps. Geol. Expl., 1872–73, p. 136.
‡ Reps. Geol. Expl., 1874–76, p. 44, and see sections on sheet facing page 50.
§ Reps. Geol. Expl., 1878–79, p. 72, and sections on sheet facing p. 88.

question.* And, further, when discussing the geology of Waiapu Valley he refers to the rocks representing the Amuri limestone as belonging to the "Cretaceous" period.†

In December of 1874 I made a collection of Tertiary marine shells from certain sandy clays in the lower part of the Maungapakeha Valley. These clays rested unconformably on soft shaly claystones containing fragments of a fibrous shell which, I have no doubt, belonged to the genus *Inoceramus*. On a subsequent visit to this district I found that the *Inoceramus* beds were associated with grey chalky clays, which are now known throughout the North Island as hydraulic limestone.

In 1888, in my report "On the Probable Discovery of Oil and Coal in Wairarapa North County,"‡ after speaking of the occurrence of hydraulic limestone on Ika Farm, I state that "this limestone is associated with the younger members of the Upper Secondary rocks"; and in the argillaceous members of these rocks I found that fragments of *Inoceramus* were not uncommon.

In the South Island the conformable relations of the Amuri limestone to the underlying Secondary beds have been acknowledged by every one, but different opinions are entertained by the Geological Survey and Captain Hutton as to the interpretation of the sections at Waipara and Weka Pass.

The chief point of contention is concerning the relations of the Weka Pass stone (Oamaru stone) to the Amuri limestone.

In South Canterbury and North Otago the Oamaru series consists of the following members in descending order :—

(*a*.) Oamaru stone.
(*b*.) Marly and sandy clays.
(*c*.) Marly greensands, often with calcareous concretions.
(*d*.) Quartz grits, fireclays, and coal.

At Waipara and Weka Pass the Weka Pass stone, which has always been acknowledged to be the equivalent of the Oamaru stone, rests directly upon the Amuri limestone. The Weka Pass stone forms a sloping plane deeply dissected by streams, and in following round the contours of the valleys is always found resting on a level or nearly level surface of Amuri limestone, thereby presenting at many places the appearance of complete stratigraphical conformity.

Since 1873 Captain Hutton has consistently maintained

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* Reps. Geol. Expl., 1886–87, p. 218.
† *Loc. cit.*, p. 218.
‡ Reps. Geol. Expl., 1887–88, p. 24.

that the Weka Pass stone was unconformable to the Amuri limestone and its associated saurian beds.*

After his first examination of Weka Pass district, in 1867, Sir James Hector referred the Amuri limestone and saurian greensands to the younger Secondary period,† but since about 1872 he has referred the Weka Pass stone, and all the beds below it down to the base of the Waipara saurian series, to the Cretaceo-tertiary series.

Thus, according to the Geological Survey the Weka Pass stone in North Canterbury is underlain conformably by beds containing a purely Secondary fauna, and in South Canterbury by beds containing only a Tertiary fauna. Placed side by side the sequence at each place is as follows :—

Cretaceo-tertiary Series of Geological Survey.

North Canterbury.	*South Canterbury.*‡
(*a.*) Oamaru (Weka Pass) stone.	(*a.*) Oamaru stone.
(*b.*) Amuri limestone.	(*b.*) Marly, sandy clays.
(*c.*) Greensands, &c., with saurians.	(*c.*) Marly greensands, with Tertiary fauna.
(*d.*) Quartz grits and lignite.	(*d.*) Quartz grits and coal.

The apparent stratigraphical continuity of the sequence at Weka Pass and Waipara has been a puzzle and stumbling-block to all geologists who have examined these places, excepting, perhaps, Captain Hutton. It is well known, however, that in many sections in the south-east of England Eocene beds appear to rest conformably on the chalk—that is, the bedding-planes of the younger beds are conformable to the surface of the chalk, which in many places presents an even or gently undulating plane.

The palæontological evidence of unconformity at Waipara between the Weka Pass stone and the Amuri series is conclusive, and I am of the opinion that the absence of the usual Tertiary members below the Weka Pass stone is due to differential movements of the land as between North and South Canterbury after the close of the Cretaceous period. The Geological Survey, still adhering to the belief that the Oamaru series contains in some places a Tertiary fauna and in others a Secondary fauna, includes all the valuable coalfields of New Zealand in one formation—namely, the Cretaceo-tertiary series.

Up till the beginning of the present year I had not examined the Shag Point coalfield, and, in deference to the opinion of the Geological Survey, had always referred the

* Reps. Geol. Expl., 1873–74, p. 30.
† Reps. Geol. Expl., 1868–69, pp. xi. and xii.
‡ As at Kakahu and Waiho, or Ngapara, in North Otago.

coalfields of New Zealand to one geological period.* Early in this year I examined Shag Valley, Horse Range, and Shag Point coalfield, and found that the Oamaru series rested unconformably on the Shag Point coal series of Cretaceous age in the manner shown first by Sir James Hector in his large geological section of Otago, prepared in November, 1864, and now in possession of the Otago University School of Mines; and afterwards by Captain Hutton, in 1875.†

The late Sir Julius von Haast also identified the unconformity between the Oamaru series and the Secondary coal-measures, but he fell into an error in placing the unconformity below, instead of above, the Moeraki *Septaria* beds.‡

The geology of Shag Valley disproves the Cretaceo-tertiary theory of the Geological Survey in the most convincing manner. Here the Tertiary coal-measures of the Oamaru series and Secondary measures of the Waipara series exist side by side, the younger abutting against the older with a degree of unconformity not often seen among the younger stratified formations in New Zealand.

The Tertiary coal-measures in the Shag Valley consist of the following members, as shown by various prospecting-works and outcrops:—

Oamaru series—

(*a.*) Oamaru stone.
(*b.*) Blue sandy clays (foraminiferous).
(*c.*) Marly greensands, with Tertiary fauna.
(*d.*) Quartz grits and conglomerates, with coal (South Palmerston coalfield).

The greatest thickness of this series obtained in the Shag Valley was 780 ft.

The succession of the Secondary coal-measures at Shag Point is as follows:—

Waipara series—

(*a.*) Shaly clays and sandstones, with septarian boulders incrusted with cone-in-cone limestone and containing saurian remains.
(*b.*) Greensands (glauconitic).
(*c.*) Ferruginous sandstones, grits, and conglomerates, with younger Secondary fossils.
(*d.*) Quartz grits, with coal-seams (Shag Point coalfield).
(*e.*) Horse Range conglomerates.

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* Trans. N.Z. Inst., vol. xxi., 1888, p. 325; and Proc. Inst. Min. and Met., London, vol. viii., 1899, p. 146.

† Hutton, "Geology of Otago," 1875, p. 44.

‡ Reps. Geol. Expl., 1872–73, p. 24.

In the line of section from Shag Point Coal-mine across Puke-iwi-tahi the thickness of the series is about 2,200 ft., of which the Horse Range conglomerates comprise probably about 1,500 ft.

In his paper "On the Relative Ages of New Zealand Coalfields" Captain Hutton states that in his opinion the coalfields of the colony may be grouped according to their age into four series, as follows:—*

4. *Pareora series*, including coalfields of (*a*) Mokau, (*b*) Waihao, (*c*) Waitaki, (*d*) Pomahaka, (*e*) Dunstan(?).
3. *Oamaru series*, including coalfields of (*a*) Bay of Islands, (*b*) Whangarei, (*c*) Drury and Lower Waikato, (*d*) Nelson and Motupipi, (*e*) Kakahu, (*f*) Green Island and Saddle Hill, (*g*) Tokomairiro and Kaitangata, (*h*) Nightcaps, (*i*) Orepuki.
2. *Waipara series*, including coalfields of (*a*) Malvern Hills, (*b*) Mount Somers, (*c*) Shag Point, (*d*) Mount Hamilton.
1. *Amuri series*, including coalfields of (*a*) Pakawau, (*b*) Wangapeka, (*c*) Westport, (*d*) Greymouth, (*e*) Reefton.

Captain Hutton considers that the Mokau coalfield belongs to the Pareora series. But is it so? On the other hand, he places the Lower Waikato coals in the Oamaru series. I am satisfied that whatever is the age of the Waikato coals is also the age of the Mokau coal.

Near Huntly and Taupiri the coal passes below marly greensands containing a marine fauna that seems the same as that overlying the coal at the Bay of Islands and Hikurangi. The greensands are followed by sandy clays, generally foraminiferous, and these are in turn overlain by calcareous sandstones, which pass insensibly into a hard limestone towards the south and west. The limestone contains *Scalaria lyrata*, a *Lima*, *Pecten hochstetteri*, and *Meoma crawfordi*, which are characteristic of the Oamaru stone elsewhere. In 1885 I traced it from the Waikato River at Taupiri westward to Raglan and southward to Waipa, Kawhia, Te Kuiti, Upper and Lower Mokau. In the Raglan district it is a yellowish-brown sandy limestone resembling the Weka Pass and Ototara stone, but proceeding south it passes into a hard shelly limestone. It should be noted, however, that the stratigraphical succession of the underlying beds down to the coal at the base of the series is everywhere remarkably uniform.

This series, which I now refer to the Oamaru series, is everywhere in this region, as follows:—

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* Trans. N.Z. Inst., vol. xxii., 1889, p. 387.

(*a.*) Limestone (= Oamaru stone).
(*b.*) Sandy and marly clays (foraminiferous).
(*c.*) Marly greensands (fossiliferous).
(*d.*) Grits, conglomerates, and coal.

Captain Hutton also includes the Waihao and Waitaki coals in the Pareora series, and this at once raises the question, Is there a Pareora series in South Canterbury or Otago? On this point there seems to be no very definite information.

Sir Julius von Haast, in his "Geology of Canterbury and Westland," 1875, page 319, like Captain Hutton, includes the Waihao and Waitaki fossiliferous beds in the Pareora series.

In 1880 Mr. McKay and the author made a collection of fossils from certain sands and sandy clays at Mount Harris, Waihao, including most of the forms which were at that time believed to be characteristic of the Pareora series, such as *Cucullaea attenuata*, *Dentalium solidum*, *Dentalium giganteum*, *Natica solida*, *Turritella gigantea*, *Dosinia sub-rosea*, *Pectunculus laticostatus*, and *Limopsis zealandica*.

At Elephant Hill these supposed Pareora beds rest on marly greensands, and, as these marly greensands form the cover of the coal, Mr. McKay placed an unconformity between them and the supposed Pareoras—that is, he placed the marly greensands below the Waihao (Oamaru) limestone and the supposed Pareoras above.* But this course was apparently followed to conform to a theoretical view, since the supposed Pareora beds wherever they occur in this district, or even in North Otago, are always found resting on the coal greensands, and never, so far as my recent investigations go, on the Waihao or Oamaru limestone.

I agree with Mr. McKay in placing the marly greensands below the Waihoa limestone, but I am of the opinion that the supposed Pareora sands and sandy clays are conformable to and form the upper horizon of the greensands, and that both underlie the Waihao limestone.

In March of this year Mr. A. Hamilton and the author made a collection of fossils at Wharekuri, in the Waitaki Valley, from certain sands and sandy clays which contained most of the forms supposed to be typical of the Pareora series, besides many corals, including some fine examples of *Trochocyathus mantelli*. It was from these beds that Mr. McKay, in 1880 and 1881, collected the remains of *Kekenodon onomata*, Hector.

The sandy beds lay conformably on marly greensands, from which we collected a large and beautifully preserved example of *Aturia ziczac*. The greensands, as pointed out by Mr.

* Reps. Geol. Expl., 1881, p. 67.

McKay, pass downwards into greysands and quartz grits and conglomerates, which in turn rest on the basement rocks.*

The sandy Kekenodon beds and underlying greensands, &c., therefore form the base of the Tertiary beds in the old Waitaki Fiord, and, proceeding westward, they pass under a yellowish-brown limestone, which Mr. McKay calls the Otekaike limestone.

I think that there can be no doubt that this limestone is the horizontal equivalent of the Ngapara (Oamaru) limestone. But, without laying any stress upon the exact correlation of the limestones, we have in the Wharekuri Basin a section of the Oamaru series exactly parallel with that at Waihao River; and there is little to wonder at in this parallelism if these beds, as seems to me likely, were deposited on the floor of the same continuous sea.

The position of the sandy beds at Wharekuri, containing, as we find, most, if not all, of the forms hitherto supposed to be typical of the Pareora series, at once raises a question as to the relations of the Awamoa and other supposed Pareoras in North Otago to the Oamaru stone. But, quite apart from the position of the Pareora beds in South Canterbury and North Otago, I am agreed with Mr. McKay that the coal at Waihao, Waitaki, and west of Oamaru occurs below the Oamaru stone.

In 1866 Sir James Hector distinguished two coal-bearing formations on the west coast of the South Island, an upper or pitch-coal series, and a lower or bituminous-coal series. This subdivision has been pretty generally acknowledged by every one from that time up to the present date, but diverse opinions have been expressed as to the relations of the two series.

The coalfields of New Zealand, in my opinion, may be grouped according to their age into two divisions, as follows :—

Oamaru series—

(*a.*) Kawakawa, Bay of Islands.
(*b.*) Hikurangi, Whangarei.
(*c.*) Ngunguru, north of Whangarei.
(*d.*) Taupiri and Huntly, Lower Waikato.
(*e.*) Waipa-Hikurangi, Upper Waikato.
(*f.*) King-country and Upper Wanganui.
(*g.*) Mokau, Upper and Lower.
(*h.*) West Wanganui, Collingwood.
(*i.*) Inangahua, Buller County.
(*j.*) Kakahu, South Canterbury.
(*k.*) Waihao, South Canterbury.
(*l.*) Waitaki, North Otago.

* Reps. Geol. Expl., 1881, p. 67.

(*m.*) Ngapara, North Otago.
(*n.*) Waikouaiti, North Otago.
(*o.*) Saddle Hill and Green Island, near Dunedin.
(*p.*) Kaitangata, South Otago.
(*q.*) Forest Hill, Winton, Southland.

Waipara series—
(*a.*) Pakawau, Collingwood.
(*b.*) Mokihinui, West Coast.
(*c.*) Westport, West Coast.
(*d.*) Greymouth, West Coast.
(*e.*) Malvern Hills, Canterbury.
(*f.*) Shag Point, North Otago.

[Note.—Since this paper was written the author has obtained evidence in North Otago and South Canterbury which confirms his conclusion that the Pareora beds underlie the Oamaru stone, and therefore belong to the Oamaru series.]

Art. XXXII.—*On the Geology of North Head, Waikouaiti, and its Relation to the Geological History of Dunedin.*

By Professor James Park, F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th October, 1903.*]

Plate XXXII.

The hill forming Waikouaiti North Head, locally known as Mount Cronin, is terminated on its south side—that is, on the side facing the inlet—by a sharply defined escarpment of great height. At the foot of this escarpment there is an immense talus which descends by a series of steep wave-like undulations towards the sea, and terminates against the shoreline in a sea-wall of irregular height, broken at intervals by breaches over which it is possible to gain the rolling surface of the talus downs above.

The talus is principally composed of large and small masses of sandstone that have slipped down from the cliffs above. It seems to owe its origin to a series of landslips in places so extensive that masses of rocks many hundreds of square yards in superficial area have settled down in such a manner as to retain their original position relatively to the horizon.

The fallen masses of sandstone forming the cliffs at the end of the sandy beach are so disposed that the original planes of deposition are nearly horizontal, thereby giving the impression, at first examination, that they are *in situ*, a decep-

tion not readily dispelled until the face of the rocky escarpment above is carefully examined. Proceeding, however, along the sea-rim of the talus from the end of the sandy beach the masses of rock forming the sea-wall are found to lie tumbled in all directions. These circumstances may be explained on the reasonable assumption that, the line of sliding being necessarily more or less parallel to the face of the escarpment, the descent of the moving masses on the slippery surface of the underlying blue clays next the inlet would be uniform and gradual, whereas at the north-east end of the escarpment, where the supporting clays would be subject to undercutting by the sea, the overhanging sandstone would be liable to break away in large blocks whenever the unsupported weight of the mass became greater than the transverse strength of the material.

Mount Cronin, when viewed from the railway-line on the south side of Waikouaiti Inlet, is seen to be dome-shaped, and to surmount the surrounding country by several hundred feet.

General Geological Structure.

A general view of Mount Cronin shows that it is composed of a series of marine sandy beds now consolidated into soft sandstones. These sandstones rest conformably on marine blue clay, and are overlain unconformably by gravel and silt beds, which in their turn are crowned by a flow of basalt.

The basalt occupies the summit of the hill, and there can be little doubt that this commanding eminence owes its present existence to this hard cap, which has protected the underlying loosely compacted gravels and silts from destruction by the ever-active agencies of subaerial denudation.

Omitting the sand-dunes, slope deposits, and other recent accumulations, we have thus in this interesting section three distinct formations—one marine, one fresh-water or terrestrial, and one volcanic. The peculiar association of these formations and their relations to each other throw a strong light on the geological history of Dunedin, and enables us to read aright sections heretofore involved in obscurity.

Classification of Rock-formations.

To facilitate description the rock-formations occurring at Mount Cronin may be classified as follows:—

Sand-dunes and talus deposits		Recent.
Mount Cronin basalt	...	Newer Pliocene.
Waikouaiti leaf beds	...	Older Pliocene.
Waikouaiti sandstone	...	Oamaru series.
Foraminiferous clays	...	

Foraminiferous Clays.

These clays form the basement rock of this place. They are exposed at the north end of Waikouaiti Beach, where they occur as a flat gently shelving plane lying below high-water mark. A few chains around the rocky beach they rise in two places into the sea-cliff, a height of some 30 ft., forming small exposures in the face of the sandstone talus by which they are surmounted and surrounded.

In most places the clays are somewhat sandy, and where exposed to the weather are friable and crumbling and of a pale-blue colour. At all the points where I examined them they were found to contain a large assemblage of *Foraminifera*, among which many genera were represented, embracing forms possessing elaborate and beautiful shell-structures. Besides *Foraminifera*, I found some fragments of minute, obscure bivalves, but the only genus I was able to identify was a small *Pecten*.

At the first cliff-exposure after leaving the end of the sandy beach the clays contain irregular bands of dark-green glauconitic sandstone varying from 1 in. to 4 in. or 5 in. thick, except at the top of the outcrop, where there is a deposit of greensand the actual extent of which is obscured by the talus. The strike of the glauconitic veins exposed at the top of high-water mark is east-and-west, and the dip south at an angle of 62°. Small nests, streaks, and spangles of iron-pyrites, some of which look like replacements of organic remains, are not infrequent in the clays and glauconitic sandstone.

The clays are so obscured by the talus that their relationship to the overlying sandstones cannot be ascertained at this place. Mr. McKay, in his report on eastern Otago,* mentioned the occurrence of calcareous sandstones at Cornish Head, but seemed to be unaware of the presence of the blue clays. In his map, however, he shows a strip of what he calls "marly clays" running from Waikouaiti Township northward through the saddle leading to Pleasant River. He does not appear to be clear as to the position of these clays, as, speaking of them (page 6), he says, "These are the probable equivalents of the Maheno marls that on the left bank of the Kakanui are seen resting on the Waireka tufas, and at the same place replace or pass under the Ototara limestone." In White Bluff, he continues, "they are overlain by a volcanic breccia." Again, on page 237 of the same report, Mr. McKay says, "These beds as they underlie the calcareous sandstones" [Ototara stone], "already described, are supposed to form part of the sequence affected by the fault along

* Reps. Geol. Expl., 1886–87, pp. 6–8.

Woolshed Creek." He further mentions, on the same page, that in the clays in the gullies south-east of Janet's Peak *Pecten zittelli*, Hutton, *Leda*, and *Foraminifera* are not rare.

We have already seen that in the flat ledges on the beach near Cornish Head the foraminiferous clays are associated with veins of glauconitic material which strike east-and-west and dip south at high angles, whereas the overlying sandstones have only a slight inclination to the southward at angles rarely exceeding 12°.

If it be held that the glauconitic veins coincide with the original bedding-planes of the clays, then we must conclude that a stratigraphical unconformity of a very marked character separates the clays and overlying sandstones. But the evidence obtainable elsewhere does not support this view. At Pleasant River and near Palmerston the calcareous sandstones (Ototara stone) are underlain conformably by greensands and blue foraminiferous clays that seem to be the stratigraphical equivalents of the Waikouaiti clays.

At Whare Flat, in Silverstream Valley, calcareous sandstones are underlaid conformably by greensands and blue sandy clays, the latter containing a large number of *Foraminifera*, among which I recognised several of the genera found in the clays at Waikouaiti Beach.

Among the *Foraminifera* from the blue clays at the end of Waikouaiti Beach I distinguished, with the kind assistance of Mr. A. Hamilton, the following genera: *Nodosaria*, four sp., *Cristellaria*, *Frondicularia*, *Rotalina*, *Vaginulina*, *Dentilina*.

These protozoans have such a wide range in time that they throw no light upon this question. The deep surface-clays between Waikouaiti and Palmerston make it impossible to trace a direct stratigraphical connection between the foraminiferous clays at these places, and consequently the relations existing between the blue clays and calcareous sandstones at Waikouaiti must still remain an open question. I am, however, of the opinion that these rocks belong to the same stratigraphical succession, and believe that subsequent investigation will confirm this view.

Waikouaiti Sandstones.

These consist of a series of soft yellowish-brown sandstones, which show a thickness of 360 ft. in vertical section in the great escarpment of Mount Cronin facing Waikouaiti Inlet. They are streaked at intervals with harder layers of a slightly more ferruginous or calcareous material, which weathers out in the face of the cliff in irregular honeycombed ledges often resembling aggregations of fucoid stems. In the upper horizons there are fossiliferous layers of a more cal-

careous character, which form low rocky ledges on the grassy slopes on the north side of the hill.

The whole series is of marine origin, and contains five distinct fossiliferous zones, which enable the beds to be divided into two well-marked groups. The lower group, corresponding to the Oamaru stone, comprises a thickness of some 220 ft. It contains four fossiliferous zones, at the following elevations: At a height of 165 ft., *Waldheimia;* 230 ft., *Meoma crawfordi, Pecten hochstetteri;* 270 ft., *Waldheimia;* 295 ft., *Waldheimia.*

In the lower zone *Waldheimias* (*Magellania*, Bayle) are scattered sparingly through a thickness of some 10 ft., in the third zone through 4 ft., and in the upper through 2 ft. Fossils are generally more abundant in the upper than in the lower zones.

The upper group of beds contains a number of forms which are common in the upper part of the Hutchison Quarry or Mount Brown beds of the Oamaru series. Among the mollusca collected were recognised *Cardita, Venus, Limopsis, Nucula, Struthiolaria;* and, among the corals, *Flabellum radians.* Besides these, there were found the casts of many minute univalves and bivalves too indistinct to be identified.

Waikouaiti Leaf-bed Series.

This series consists of a succession of silts, sands, and gravels about 45 ft. thick resting unconformably on a slightly denuded surface of the marine sandstones. The sediments of this series, from their fluviatile or lacustrine origin, are subject to great variation in thickness, and this is especially noticeable in the case of the gravel and sand beds, which present the arrangement of current-bedding characteristic of deposits of this kind. On the west side of the cliff, under the trig. station, they consist of the following members in descending order:—

	Ft.
1. Sands and silts, with ferruginous concretions	7
2. Gravels	2–6
3. Gritty sands	8
4. Coarse gravels	7

The leaf-bed series, at the seaward end of the escarpment, consists of the following sequence, which naturally shows a close correspondence with that below the trig. station:—

	Ft.
1. Sands and grits	12
2. Grit-bed	3
3. Grey silts and sands	8
4. Coarse gravels	18
5. Leaf bed—fine grey silts	6

The leaf bed thins out toward the westward, and disappears altogether some yards before a point below the trig. is reached. The material composing this bed consists of excessively fine grey pumice sand or silt, in which occur numerous inclusions of grey pumice, occurring in rounded fragments, seldom exceeding 2 in. in diameter, but generally under 1 in. This is interesting as the first discovery of bedded pumice in any part of the South Island of New Zealand.

The leaf-impressions are numerous and not well preserved. They include what appear to be representatives of beech, myrtle, oak, elm, and some ferns. The leaf bed is the lowest member of the series, and is overlain by a bed of coarse gravel of variable thickness, which can be traced continuously from one end of the escarpment to the other. The gravels consist principally of pebbles and boulders of basanite and phonolite.

The basanite is blackish-green in colour, fine-grained in texture, and shows conspicuous crystals and grains of nepheline. When examined in polarised light it is found to be principally an aggregate of plagioclase, augite, olivine, and nepheline. The base is greyish-blue in colour, not abundant, and crowded with small laths and microlites of feldspar. The augite and olivine occur in large well-developed phenocrysts. The olivine is generally much altered and serpentinised. The nepheline occurs in large grains and in crystals often imperfectly developed. A little sanidine, biotite, apatite, and magnetite are present. In many places the rock is tinged red with iron-peroxide, evidently due to the oxidation of magnetite.

About 15 yards south of the trig. station the leaf-bed series and the underlying sandstones are traversed by a fault which hades to the south at an angle of about 45°. The vertical displacement of the beds caused by this fault is about 40 ft.

Two minor faults with a displacement under 10 ft. can be traced indistinctly on the seaward side of the escarpment, near the outer rim of the basalt-flow.

BASALT-FLOW.

The summit of the hill is occupied by a flow of basalt which is probably a remnant of the flow which crowns the summits of Mount Royal, Mount Mackenzie, Mount Watkins, Derdan Hill, and other prominent elevations in the neighbourhood. These isolated patches are all that now remain of the basalt plateau that formerly extended from the Shag Valley southward to Waitati, and from the schistose mountains on the west eastward to the sea.

The basalt is fine in texture. Under the microscope it is seen to consist principally of plagioclase, augite, and olivine. The base is bluish-grey in colour, but not abundant. It is crowded with microlites of feldspar and augite, and thickly dusted with grains of magnetite. The feldspars occur as long narrow laths. The phenocrysts show orientation in one general direction, which doubtless indicates the original plane of fluxion. A little sanidine and apatite are present.

The existence of this outlier of basalt proves that the sculpturing of the present contours has taken place since the close of the Pliocene—that is, after volcanic activity had ceased in this part of Otago.

General Conclusions.

The Tertiary marine sandstones, leaf-bed series, and overlying flow of basalt are exposed in vertical section in a face of steep escarpment nearly 200 yards long and 400 ft. high. The face is bare or covered only with a scanty vegetation, thereby enabling the actual junction of the different formations to be examined at many points of contact.

The geological relations are so clear that the Waikouaiti section thus becomes of almost classic value when considered in connection with the sequence of events that constitute the geological history of the neighbourhood of Dunedin and the region round about Mount Cargill and Waitati.

Unconformity of Dunedin Volcanic Rocks to Oamaru Series.—Within the watershed of the Waitati, Silverstream, and Kaikorai Streams the great pile of volcanic ejecta which forms the hills around Dunedin is found resting upon different members of the Oamaru series, of which the Waikouaiti sandstone forms a part.

An examination of the geological structure of the neighbourhood of Dunedin shows that the Caversham sandstone had been elevated and in some places highly denuded before the commencement of volcanic activity in that region. The unconformity between the marine series and volcanic rocks is so well marked as to indicate a considerable lapse of time between the formation of the one and the eruption of the other.

Unconformable Relations of Leaf-bed Series to Oamaru Series.—No one seems to doubt that the Waikouaiti sandstone is the horizontal equivalent of the Caversham sandstone. When, therefore, we find terrestrial beds composed of material derived from volcanic rocks that lie unconformably upon the Caversham sandstone near Dunedin resting upon equivalent marine beds at Waikouaiti, we can only conclude that even a greater unconformity in time exists between the terrestrial beds and marine series at Waikouaiti than between

the parent volcanic rocks and marine sandstones near Dunedin.

Source of Basanite and Phonolite in Gravels.—The gravels underlying the basalt-flow at Mount Cronin are, as we have seen, principally composed of basanite and phonolite.

In his excellent paper on the lithology of Dunedin, Professor Ulrich pointed out that the great mass of the volcanic material in that region belonged to the phonolite group of rocks, in which nepheline forms an essential component; while some, he said, through accession of plagioclase, and either absence or presence of olivine, graduate respectively towards tephrite and basanite.* Since no basanite or phonolite is known in the neighbourhood of Waikouaiti, we may conclude that the Mount Cronin gravels were derived from the erosion of the basanites and phonolites described by Professor Ulrich at Mount Cargill and Purakanui.

Age of Volcanic Rocks around Dunedin.—I have just shown that the materials forming the gravel and sand beds at Mount Cronin are principally volcanic, and in all probability derived from the denudation of the volcanic area lying between Waitati and Dunedin. Before, therefore, discussing the age of the leaf beds it will be necessary, in the first place, to consider the probable age of the volcanic rocks in that area.

The volcanic rocks around Dunedin rest on a deeply eroded surface of the Caversham sandstone and underlying quartz sands and grits.

The Oamaru series, to which these rocks belong, is considered by Captain Hutton to be of Oligocene age; but the proportion of fossils belonging to living species in that formation would indicate, from European standards, rather a Miocene age. If, however, we accept the Oligocene age of Captain Hutton, it is evident that the earliest volcanic outbursts could not have commenced until some time in the Miocene period, for we find that the Caversham sandstone, one of the higher members of the Oamaru series, was deposited, consolidated, elevated, and partly denuded before the first outbursts began.

There is no evidence of contemporary volcanic activity during the deposition of the Oamaru series anywhere south of Palmerston. There is, we know, abundant evidence that volcanic outbursts took place during the deposition of the middle members of the Oamaru series in the Oamaru basin. But these outbursts were purely local, and there is nothing to show that they reached north of the Waitaki or south of the Shag River. At any rate, south of Palmerston the

* Proc. Aust. Assoc. Adv. Science, vol. iii., 1891, p. 145.

marine Tertiary series is quite free from volcanic material. It cannot therefore be said that the eruptions around Dunedin were a recrudescence of Oligocene activity.

It is pretty clear that volcanic activity commenced in the Dunedin area after the Caversham sandstone had been subject to subaerial erosion, and for that reason I am disposed to place the first outbursts in the later period of the Miocene, or in the beginning of the Pliocene.

Age of Waikouaiti Leaf Beds.—I have already shown that the materials composing the leaf-bed series at Mount Cronin were in all probability derived from the south, principally from the watershed formed by Mount Cargill range. If the pile of volcanic ejectamenta forming that watershed and neighbourhood was the result of Miocene eruptions, and suffered subaerial erosion sufficiently prolonged to yield the materials to form fluviatile or lacustrine beds at a place over twenty miles distant, it is evident that the said beds cannot be older than Pliocene. This conclusion is drawn from the fact that the leaf beds are composed of materials derived and transported by fluviatile action from a region where the parent rocks rest on a highly denuded surface of a marine formation of Oligocene or Lower Miocene age.

So far the fossil flora of these beds has not been submitted to a palæobotanist; but, in any case, such determinations, except they are supported by other data, must always be regarded with suspicion.

For the present, therefore, until better evidence is forthcoming, I am inclined to place the leaf beds in the older Pliocene—that is, contemporary with the Wanganui older marine series, and about synchronous with the lacustrine beds of central Otago.

Bearing of Waikouaiti Section on Geological History of Dunedin.—From this section we learn that the piles of volcanic rocks around Dunedin were the result of at least two distinct periods of volcanic activity. And the presence of pumice, phonolite, and basanite in the leaf-bed series would tend to indicate that the earlier eruptions were of an acidic or semi-basic type.

The materials composing the gravels of the leaf-bed series were, as we have seen, apparently derived from the erosion of the ejecta of the earlier eruptions, and we can only explain their presence by assuming that these earlier outbursts were succeeded by a period of volcanic quiescence during which the newly ejected rocks were subjected to subaerial denudation.

The basic eruptions of the second period of activity smothered the newly formed gravels in the protecting cap of basalt which now crowns Mount Cronin and the higher hills in the neighbourhood.

It is not assumed that the ejecta of each era was the result of one stupendous outburst. On the contrary, the alternation of fragmental matter and solid lava so often seen in the district around Dunedin seems to justify the conclusion that in each era there were alternating periods of quiescence and more or less paroxysmal activity, each distinguished by some peculiarity in the composition of its lavas and fragmental material.

The conclusion that a cessation of volcanic activity occurred after the earlier outbursts does not depend alone upon the evidence furnished by the section at Waikouaiti North Head. At several places within the Dunedin area there is seen a series of aqueous deposits both underlain and overlain by volcanic rocks.

This sedimentary series consists of well-rounded gravels, sands, and silts containing in places leaf-impressions, and in others such an excess of carbonaceous matter as to pass into impure coal and oil-shale.

At the oil-shale outcrops between Burns's and Williams's Streams, at the source of the Waitati, the succession of rocks in descending order is as follows:—

		Ft.
	1. Basic lava-flow of great thickness.	
Probably lacustrine	2. Oil-shale graduating into carbonaceous sandstone	18
	3. Volcanic tuff partially stratified ...	12
	4. Impure brown coal	3
	5. Volcanic tuff	12–15
Marine ...	6. Caversham sandstone.	

The tuff underlying the oil-shale contains numerous fragments of grey vesicular material resembling the pumice in the leaf bed at Mount Cronin.

In the Kaikorai Valley the Caversham sandstone is overlain by a series of beds of lacustrine origin, consisting of fine grey silts, sands, clays, and gravels composed principally of volcanic material. The lacustrine beds are overlain by a great pile of volcanic rocks.

The grey silts contain a large number of finely preserved leaf-impressions, and in a collection of these made in 1901 Dr. Marshall identified species of oak, elm, birch or beech, *Magnolia*, *Piper*, and *Metrosideros*.*

The Kaikorai section has a striking resemblance to that at Waikouaiti North Head, and there seems to be no reason to doubt that the leaf-bed series at Mount Cronin is the horizontal equivalent of the Kaikorai leaf beds.

In all that has been written about the geology of Dunedin it is singular that the significance of the section exposed at Te

* Trans. N.Z. Inst., vol. xxxiv., 1901, p. 586.

Manu Hill, locally known as Tanna Hill, situated near the University Mining School, has been entirely overlooked. Here we have a succession of rocks almost identical with that at Waikouaiti North Head and at Kaikorai Valley.

A few yards below Union Street Bridge, in the steep bank of the Leith, is seen a bed of grey silts containing a few imperfect leaf-impressions, numerous broken plant-remains, and a few larger pieces of carbonised driftwood. The silts are not continuous for more than 25 yards, and, so far as they are exposed, they thin out in both directions against a coarse tuff-like sandstone. They exhibit characteristic current-bedding. Overlying the plant bed there is a deposit of gravels and sands composed principally of volcanic material. The gravels in their turn are capped by the flow of rudely columnar basalt which forms this well-known eminence. A deposit of volcanic-ash rock rests on the undulating surface of the basalt. In the bed of the stream, under the bridge, the plant silts are seen resting on coarse volcanic breccia or agglomerate.

The succession in this important and interesting section is therefore as follows :—

1. Surface clays and soil.
2. Volcanic ash from 8 ft. to 15 ft. thick.
3. Basalt-flow, about 25 ft.
4. Gravels, about 18 ft.
5. Grey plant silts, 5 ft. to 7 ft. thick, resting at ends against tuff-like sandstone of variable thickness.
6. Coarse volcanic breccia.

At Waikouaiti, Kaikorai, and Waitati the plant-bed series rests directly on the Caversham sandstone, and at Te Manu Hill on fragmentary volcanic ejecta. The lesson to be derived from this is that Dunedin was situated within the theatre of volcanic activity during the period of the earlier outbursts.

Te Manu Hill is a place of great geological value, and I trust that the exigencies of the University will not require its removal, but that it will be reserved for all time as a geological witness of the past history of Dunedin. Its destruction would be an irreparable loss to geologic science, and cause the obliteration of a geological record that could never be replaced.* Apart also from its geologic and scenic value, Te

* Mr. A. Hamilton informed me, after this paper was prepared, that no interest had previously been attached to Te Manu Hill by geologists because it was believed that the gravel and silt beds were of comparatively recent date, and abutted against the basalt instead of underlying it. In order to put this question beyond all doubt I caused a pit to be sunk in the floor of the old quarry facing the Mining School, and trenches to be dug at the foot of the cliff on the Leith Street side of the hill. In all places the gravels were found below the basalt-flow, as described above. —J. P.

Manu Hill is an ideal site for the University astronomical observatory.

Duration of Volcanic Cessation.—The means to determine this are only comparative. The leaf beds at Waikouaiti and Kaikorai and the shale-beds at Waitati rest directly on the Caversham sandstone, from which we gather that the earlier eruptions did not reach these areas.

On the other hand, the fine silts, muds, and ash at these places clearly indicate that showers of finer ejecta at times fell in the lake-basin in which these deposits were forming, and doubtless also on the surrounding country. The gravel-beds which close the leaf-bed series, moreover, prove that fluviatile forces were active agents of erosion immediately prior to the beginning of the second and final era of volcanic activity, which culminated in the emission of the lavas overlying the gravels.

The plant-remains in the muds and silts inform us that a varied forest vegetation grew on the shores of the Pliocene lake; while the oil-shale at Waitati may be held to indicate the existence of a rich and long-continued growth of fresh-water gelatinous algæ or related forms.

At Te Manu Hill, near the Mining School, the silt and gravel series rests on a surface of coarse volcanic breccia, a circumstance which clearly indicates that the eastern shores of the Pliocene lake reached to the area affected by the earlier volcanic eruptions.

The gravels and tuffs which close the leaf-bed series seem to have suffered little or no erosion prior to the renewal of volcanic activity. They were apparently overwhelmed suddenly by stupendous outbursts, more violent and widespread than those of the earlier period of eruption. We may therefore conclude that the period of cessation was approximately equivalent to the time required for the deposition of the intercalate leaf-bed series.

After the period of cessation volcanic activity commenced anew, culminating in the more basic outbursts in newer Pliocene times.

Direction of Drainage in Pliocene Times.—A study of the section at Mount Cronin affords some interesting information respecting the conformation of the land during the interval of volcanic cessation.

Professor Ulrich showed that the volcanic rocks around Dunedin graduated from trachytoid phonolites to basanite.* The preponderance of phonolite and basanite in the Mount Cronin gravels is therefore highly instructive. It shows, in

* Trans. Aust. Assoc. Adv. Science, vol. iii., 1891, p. 145.

the first place, the southern origin of the leaf-bed material; and, as this material is obviously water-borne, it establishes the former existence of a drainage system running from south to north—that is, from Dunedin towards Waikouaiti, in a direction more or less parallel with the general trend of the present coast-line.

Again, the physical conditions and distribution of the materials in the different members of the leaf-bed series tend to show that this drainage system comprised a river with one or more shallow lakes along its course.

This ancient watershed required for its outer or eastern rim the existence of a land-area to seaward of the present coast-line, and it just suggests itself that this rim was probably formed of volcanic ejecta piled up during the earlier period of eruption. At any rate, there is evidence that the earlier eruptions did not extend so far south, west, or north as the later outbursts, but were centred in the neighbourhood of Port Chalmers, Purakanui, and Mount Cargill.

The geological history of volcanic activity around Dunedin in Tertiary times bears a peculiar likeness to that of the Hauraki goldfields of Auckland. After a study of the latter extending over seven years, I wrote in 1897 as follows: "After the pent-up forces had spent themselves in the first great paroxysm there was a period of rest, during which vegetation established itself on the muds and ashes washed into the low ground by the streams draining the slopes of the newly formed volcanoes. The land, however, was in a continued state of tremor, and the oscillations were too frequent to permit the continued growth and accumulation of sufficient vegetation to form workable seams of coal. The cessation of volcanic activity was of short duration. The plutonic forces burst out with renewed energy. The forests were devastated and utterly destroyed, and covered with hundreds of feet of ashes and solid lava of semi-basic character."*

DESCRIPTION OF PLATE XXXII.

Section, Waikouaiti North Head.

1. Talus deposit.
2. Basalt-flow.
3. Gravels and sands.
4. Grey sandstone.
5. Calcareous sandstone.
6. Blue clays, foraminiferous.

Section of Summit of Mount Cronin.

2. Basalt-flow.
3*a*. Grey sands and silts.
3*b*. Coarse grits.
3*c*. Grey silts and sands.
3*d*. Coarse gravels.
3*f*. Sandy grits.
4. Grey sandstone.

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* Park, "The Geology of the Hauraki Goldfields," 1897, p. 43.

Art. XXXIII.—*On the Jurassic Age of the Maitai Series.*

By Professor James Park, F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 9th June, 1903.*]

Plates XXXIII. and XXXIV.

Rocks belonging to this formation are widely distributed in New Zealand, and play an important part in the structure of the mountain-ranges in both Islands. In the neighbourhood of Nelson, where they are typically developed, they consist of a great assemblage of greenish-grey sandstones, blue, green, red, and grey slaty shales, and limestones, with a few subordinate beds of red and green slaty breccia. The blue or green shales often alternate with thin laminæ of grey shale or sandstone.

The average general bearing is N. 20° E. (true bearing). The arrangement of the strata is displayed to great advantage in the valleys of the Matai, Brook Street, and Roding Streams, which descend from the Dun Mountain region at nearly right angles to the trend of the series. The beds are seen in all three lines of section to be arranged in a great synclinal fold.

The strata on the western side of the syncline — that is, immediately behind the Town of Nelson—are associated with massive sheets and numerous ramifying dykes of a chloritic basalt,* and on the eastern side by a remakable development of altered ultra-basic rocks, principally peridotite and serpentine, the latter often traversed by veins of bronzite, hypersthene, and other pyroxenes.

The eruption of these igneous rocks was probably contemporary with, or at least not much later than, the deposition of the beds with which they were associated.

Age of Maitai Series.

The late Dr. Von Hochstetter, who examined these rocks in 1859, referred them to the Lower Trias,† placing them conformably under his Richmond sandstone, the equivalent of the Wairoa series of Sir James Hector. He described them as containing no fossils, and apparently ascribed them to the Triassic period, from their association with the Richmond sandstone, in which he found *Monotis salinaria* var. *richmondiana*, Zittel, a typical Trias form in Europe.

Sir James Hector, in the Catalogue of the Colonial Museum, 1870, in his "Synopsis of the Arrangement of the Formations represented by the Collections of Fossils," also

* Hutton, Proc. Roy. Soc. N.S.W., 1889, p. 152.

† Hochstetter's "New Zealand," 1867, page 57.

placed the Maitai series at the base of the Trias, between the Wairoa and Kaihiku series.

The late Mr. E. H. Davis, in his very excellent report on the geology of Nelson District, referred to the Maitai series as Triassic.* In the limestones at the base of the series he found *Inoceramus* and corals; and in the slates above the limestone numerous annnelid trails, *Inoceramus* in great numbers, a cast of a cephalopod, and casts of fossils not determined.

Captain Hutton, F.R.S., in his "Report on the North-east Portion of the South Island," in 1873, reversed the relative positions of the Maitai and Wairoa formations: thus, while the Wairoa series is still retained in the Trias, the Maitai series, on palæontological and stratigraphical grounds, is placed in the Jurassic system.†

In the same year Sir James Hector examined the sections exposed in the Wairoa Gorge, and in his Progress Report states that in his opinion the Wairoa formation—that is, the Richmond sandstone of Hochstetter—rests unconformably upon the Maitai formation, and accordingly reverses the order of superposition proposed by Captain Hutton. He still retains the Wairoa formation in the Trias, and now relegates the Maitai formation to the Upper Palæozoic, placing it below his Te Anau series.‡

In his classification of 1877 the Maitai formation is placed by Sir James Hector in the Permo-carboniferous period in association with the Nuggets and Mount Potts beds;§ and in his classification of 1878 it is pushed down into the Carboniferous.‖

Mr. A. McKay, F.G.S., in the year 1878, examined the lines of section detailed so minutely by Mr. Davis in 1869, and at the same time extended his observations to the neighbourhood of the Wairoa Gorge and Mount Heslington. In his report he adopts the classification of the Director of the Geological Survey for the Wairoa and Maitai formations, but, unlike previous observers, places the Maitai limestone at the top instead of at the base of that series, and supports this view by stating that he considers the Maitai formation to be overturned.

In the following year Mr. McKay made a further examination of the Wairoa and Mount Heslington districts, and, besides making large collections of fossils from the Maitai and Wairoa formations at different points, discovered what he

* Reps. Geol. Expl., 1869–71, p. 103.
† Reps. Geol. Expl., 1873–74, p. 34.
‡ Geological Map, Hector, 1873; and Reps. Geol. Expl., 1876–77, p. 1.
§ Reps. Geol. Expl., 1876–77, p. v.
‖ Reps. Geol. Expl., 1877–78, p 198.

believed to be an outcrop of fossiliferous Permian rocks in Eighty-eight Valley district, near Wakefield.

Among the fossils collected from the limestone at Sellen's and Wairoa Gorge he says that Dr. Hector identified "*Spirifera bisulcata* and *Productus branchythærus* among the *Brachiopoda*, and the genera *Cathophyllum* and *Cathocrinus* among the corals."* On this occasion he places the limestone at the base of the Maitai series, instead of at the top, as he did in 1878.

In the summer of last year I made an examination of the sections of the Wairoa and Maitai formations exposed in the Maitai Valley, along the Dun Mountain tram-line, at Wairoa Gorge, Mount Heslington, and Eighty-eight Valley, at the same time making collections of fossils at all available places.

In the Wairoa Gorge I observed that the dip and strike of the two formations were the same at every point of exposure. I further noted that the dip of the higher *Mytilus* beds, granitic conglomerate, and associated strata was such as to carry the Wairoa series conformably below the limestone at the base of the Maitai formation.

So far as I could determine after an examination of many sections, the two formations seemed to form a continuous sequence, the Wairoa series occupying the inferior position, as reported by Captain Hutton in 1873.

The result of my observations at the Wairoa Gorge induced me to examine the sections of the Trias in Eighty-eight Valley, more especially those exposed in the vicinity of Well's Creek, where Mr. McKay reported the discovery of supposed Permian (Kaihiku) beds in 1878. A detailed examination of the very clear section exposed along the right bank of Well's Creek showed that the supposed Permian beds occurred at the top and not at the base of the Wairoa series, as reported by Mr. McKay, and this discovery led me to conclude that there was possibly some association between the Wairoa limestone and the so-called Kaihiku beds, which in places are richly fossiliferous and often highly calcareous.

In November of this year I again re-examined these sections, and also extended my observations to the sections exposed at Sellen's run and Roding River. The result of my work on this occasion was to fully confirm my former conclusions—namely, that

(*a.*) The Wairoa series lies conformably below the Maitai formation.

(*b.*) The supposed Permian strata in Eighty-eight Valley are probably the equivalent of the Maitai limestone.

* Reps. Geol. Expl., 1878–79, p. 117.

We have already seen that Captain Hutton, in his report on the north-east portion of South Island in 1873, placed the Maitai formation above the Wairoa series, classifying the former as Jurassic and the latter as Triassic.

In his Progress Report for the year 1873 the Director of the Geological Survey states that, after an examinaton of the sections relied on by Captain Hutton, he had arrived at the conclusion that the relative positions of these formations as reported by Captain Hutton must be reversed, "as the section up the gorge of the Wairoa River shows the latter" [Wairoa] "formation, with its characteristic fossils (*Monotis salinaria* and *Mytilus problematicus*), to rest unconformably on the 'Maitai' formation."* Unfortunately, he omitted to furnish details of the section showing this unconformity, and in the absence of specific data it is impossible to review the evidence on which he based his conclusion.

In his reports of 1877 and 1878 Mr. McKay adheres to the classification of Dr. Hector. He examined the typical sections exposed in the Maitai Valley, Brook Street Valley, Roding River, Wairoa Gorge, Sellen's, and Eighty-eight Valley, and, although in no case do his descriptions possess the elaborate exactness of those of Mr. Davis, I found that his field observations were everywhere carefully noted and faithfully recorded. On the other hand, in his discussion on the relative positions of the Wairoa and Maitai formations his conclusions seem curiously at variance with the recorded facts, while some of his sections are obviously constructed to represent his views rather than the facts observed in the field.

Proceeding from the Waimea Plain through the Wairca Gorge, and thence along the course of the Roding River, there is exposed a clear section of the Wairoa and Maitai formations in which the dip is continuously to the east-south-east in one unbroken sequence, at angles generally between 65° and 75°, representing in a distance of a mile and a half a thickness of not less than 7,000 ft. of strata. In this section the Trias beds appear first, and are clearly seen to dip under the Maitai limestone.

At a point just above the first bend in the Roding River the beds dip west-north-west at an angle of 75°, and thence, following up the river, the whole sequence of the Maitai formation is repeated down to the limestone and associated conglomerates, beyond which appear the eruptive rocks of the serpentine belt. This synclinal arrangement of the overlying Maitai formation is also observed in the Maitai River and Brook Street Valley sections.

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* Reps. Geol. Expl., 1873–74, p. ix.

The Trias formation consists of a great series of claystones, coarse and fine sandstones, and granitic conglomerates, containing a number of well-marked fossiliferous horizons, to which reference will be made later when describing the section in Eighty-eight Valley.

A careful examination of the pebbles and boulders forming the conglomerates shows that they consist principally of diorites, granite, and a great variety of acidic, eruptive, and quartzose material, all of which have been apparently derived from the granitic masses in the Mount Arthur district, lying to the north-west of this, where these rocks occur *in situ*, associated with rocks of Silurian age.

It is a significant fact, and one quite in harmony with the stratigraphical evidence, that the ultra-basic eruptive rocks which occupy so conspicuous a place in the Maitai formation are quite absent from the Trias conglomerates.

The Maitai formation and its colossal pile of basic eruptives form a long chain of broken uplands, on the lower flanks of which the Wairoa beds form a corresponding chain of foot-hills. Hence, if the Maitai rocks were antecedent with the Wairoas resting on their denuded surfaces, as contended by Sir James Hector and Mr. McKay, fragments of the basic eruptives should be largely represented among the coarser sediments of the Wairoa beds; but they are entirely absent, as, indeed, could not be otherwise from their subsequent date.

The Maitai rocks have generally been described as slates of various colours. This is a somewhat loose use of the term "slate." The rocks are not really slates, but bluish-grey claystones, which often occur in thin laminæ of different shades of colour. When these thin laminæ alternate with each other, as is often the case, the rock gets a slaty or flaggy appearance. In places the claystones are slaty and somewhat fissile, with a silky lustre where they have been much crushed. In the lower part of the formation there are thick beds of grey sandstone and greywacke, generally much shattered and jointed, and often streaked with white veins of a hydrated mineral which was determined by the late Mr. W. Skey to be stilbite. Thin veins of grey and brown flinty quartz occur in the harder sandstones in several places.

Beds of red and green slaty claystones and breccias occur interbedded in the formation. They are quite subordinate in extent to the claystones and sandstones, but wherever they occur they are very prominent from their conspicuous colour.

Mr. McKay, referring to the Wairoa section, says, "In the lower part of the Roding River, near its junction with the Wairoa, the junction between these beds is strictly analagous

to that made between the Wairoa and Maitai rocks behind Richmond, already described."* And on the preceding page, after describing the Richmond section, which lies a few miles further north, he says, "Perhaps, upon the whole, it may be said that this section does not favour the theory which aims at showing the Wairoa formation to be the younger of the two."†

Mr. McKay seems unwilling to admit the inferior position of the Wairoa formation no matter how clearly indicated by the stratigraphical evidence, and to get over the difficulty argues that the Trias rocks must be arranged as an "inverted syncline," basing this last supposition on the repetition of the *Mytilus problematicus* beds, which he considers must be due to the complete inversion of one side of the supposed syncline. He mentions, however, that the *Mytilus* bed was the only one which seemed to be repeated, and in this he admits a serious difficulty. An examination of the Mount Heslington‡ and Eighty-eight Valley sections shows that the repetition of the *Mytilus* bed is due not to inversion, but to the simple circumstance that there are two distinct horizons of *Mytilus*, one near the middle of the Trias, and one below the upper granitic conglomerate lying below the Maitai limestone.

In the section at Sellen's run, a few miles south of the Wairoa Gorge, the Trias and Maitai rocks dip east-south-east at high angles, the former again occupying the inferior position. Writing of this section, Mr. McKay says, "On the ridge east of the limestone at Sutton's" [Sellen's] "these beds" [Wairoa beds] "again dip as though they would pass under the Maitai series,"§ and in this instance his diagrammatic section along this line correctly shows the Trias rocks dipping conformably below the Maitai limestone as they are actually seen to do.

The Trias rocks in the section on the north-east side of Well's Creek, in Eighty-eight Valley district, a few miles south of Sellen's line of section, are again seen to dip conformably below the Maitai formation. Here the whole series is clearly exposed in a regular sequence, dipping to the south-south-east at angles varying from 50° to 75° or 80°, the inclination of the beds becoming steeper in ascending order to the eastward.

Speaking of this section, Mr. Mackay says, "Along their junction with the Maitai series the beds" [Wairoa beds] "are much crushed and highly indurated, but a short distance

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* Reps. Geol. Expl., 1877–78, p. 156.

† *L.c.*, p. 155.

‡ Mr. McKay, in his reports, erroneously speaks of this hill as Mount Wellington.

§ Reps. Geol. Expl., 1877–78, p. 157.

to the north-west of the boundary-line the strike and dip of the beds are regular in such a direction that the beds appear to pass under the older beds" [Maitai beds] "lying to the eastward."* For "older beds" he should have written "supposed older beds."

Here again Mr. McKay attempts to explain away the very plain stratigraphical evidence in the following words:—

"It is highly probable that what are now the higher beds, as seen in the section along the banks of the creek, are in reality the lower beds, and that they are now in an overturned position."† Thus, while correctly noting and recording the stratigraphical evidence, which shows the inferior position of the Wairoa formation in all the sections examined, in order to support the theory that the Maitai formation is older than the Wairoa formation he assumes that the combined strata of both formations, representing a thickness of 7,000 ft. or 8,000 ft., have been completely overturned; and, having thus overturned the formations, argues that the Maitai formation, which everywhere admittedly occupies the superior stratigraphical position, is Carboniferous, and the inferior or underlying formation Triassic.

The gritty, pebbly, calcareous sandstones and claystones immediately overlying the upper granitic conglomerate in Well's Creek section are seen to dip under the Maitai rocks. They contain a large assemblage of fossils, mostly brachiopods, and, although they occur at the top of the Trias series, they become by the process of inversion the bottom beds, and have been referred by Mr. McKay to the Permian. Disregarding, however, this supposititious inversion of the formations, and reading the sections as they appear, the sequence of the Trias rocks in the different sections is found to be approximately the same as would naturally be expected in lines of section across the same basin of deposition.

In the Wairoa section the beds in descending order are as follows:—

0. Fossiliferous limestone (Maitai—*i.e.*, Wairoa—limestone).
1. Claystones.
2. Upper granite conglomerate.
3. *Mytilus* sandstones and claystones.
4. *Spirigera* sandstones.
5. *Mytilus* sandstones.
6. *Monotis* sandstones.
7. *Spirigera* and *Trigonia* sandstones.
8. Lower granite conglomerate.

* Reps. Geol. Expl., 1878–79, p. 118.
† *L.c.*, p. 118.

9. *Halobia* claystones.
10. *Spiriferina* claystones.

In Sellen's section the sequence is :—

0. Fossiliferous limestone (Maitai limestone).
1. Claystones.
2. Upper granitic conglomerate and grit-stone.
3. Claystones (no *Mytilus* seen).
4. Sandstone and claystone, with *Mytilus* at base.
5. Lower granite conglomerate.
6. Claystones, with *Halobia*.
7. Sandstones and claystones, with *Halobia*, *Rhynchonella*, *Spiriferina*, and corals.
8. Plant beds.

One of the clearest sections of the Trias rocks is exposed in Well's Creek, where the sequence is as follows :—

0. Fossiliferous calcareous gritty sandstone.
1. Claystones.
2. Upper granite conglomerate.
3. *Mytilus* sandstones and claystones.
4. *Spirigera* sandstones.
5. *Mytilus* sandstones.
6. *Spirigera* sandstones.
7. Lower granite conglomerate.
8. *Halobia* claystones.
9. *Spiriferina* claystones and sandstones.
10. Plant beds.

In the Wairoa and Sellen's sections the Trias formation is closed with a limestone (the Maitai limestone of Hector), from which I collected *Spiriferina* (two sp.), *Athyris*, *Rhynchonella*, *Pleurotomaria*, *Inoceramus*, *Pentacrinus*, and corals (three sp.).

In many places the limestone is argillaceous, gritty, and pebbly. It has been broken and shattered into small angular fragments, which have been recemented by white veins of calcite. Fossils are not at all common, and where found are difficult to extract in a complete state on account of the jointed and veined condition of the material. Of the different forms present *Inoceramus* was found to be the most abundant.

Among the collections made by Mr. McKay Sir James Hector is said to have identified the Carboniferous forms *Spirifera bisulcata*, *Productus branchythærus*, and the genera *Cathophyllum* and *Cathocrinus* among the corals.* Considering the imperfect character of most of the specimens and their association with *Inoceramus*, a good deal of doubt must necessarily attach to these determinations.

The large brachiopod identified as *Spirifera bisulcata* seems

* Reps. Geol. Expl., 1878–79, p. 117.

to be related to the peculiar form of *Athyris* called *Clavigera* by the Geological Survey. Should it, however, on examination, prove to be a true Spirifer, it would show that this genus persisted in New Zealand up to the close of the Trias.

A calcareous, pebbly, and gritty sandstone in Eighty-eight Valley closes the Trias sequence, and occupies the same relative position to the upper granite conglomerate that the limestone (Maitai) does to the same conglomerate in the Wairoa sections. From it I collected *Spiriferina* (two sp.), one of these the *Rastelligera* of Hector, *Athyris* (two sp.), *Epithyris*, *Rhynchonella*, *Pleurotomaria*(?), *Patella*, branching corals, *Pentacrinus*, and fragments of saurian remains, which may probably be referred to *Ichthyosaurus*.

Among the *Athyris* (*Spirigera* of D'Orbigny) in this horizon there are two very unusual forms. They have a long straight hinge-line, and a distinct area. They are smooth, gibbose, impunctate, and possess a gentle mesial sinus in each valve, the sulcation being more distinct in the ventral valve than in the dorsal. The ventral valve is provided with strong prominent hinge-teeth, one on each side of the deep triangular notch which in *Spirifera* is closed by pseudo-deltidium.

The two species differ widely in external form. One species has rounded cardinal angles resembling those of *Athyris expansa*, Phillips, or some of the straight-hinged *Terebratula*, such as *Terebratula (Megerlia) suessi*, E. Desl., of the English Lias; the other, sharp cardinal angles like some species of *Argiope*.

The section of the Trias rocks at Roaring Bay, near Nugget Point, in Otago, supplies the most complete confirmation of the reading of the section in Eighty-eight Valley. Along the coast-line there is exposed a thickness of over 2,500 ft. of strata in one continuous sequence, representing the whole of the Trias formation from the base of the *Spiriferina* beds to the summit of the *Athyris* beds. The different horizons represented in this section are as follows, in descending order:—

1. *Athyris* beds—coarse pebbly calcareous sandstones.
2. Coarse sandstones.
3. *Mytilus* and oyster bed.
4. Claystones.
5. *Trigonia* and *Spiriferina* beds.
6. Granite conglomerate.
7. Sandstones, with beds of claystone.
8. Breccia conglomerate.
9. Claystones.
10. Breccia conglomerate.
11. Claystones (*Halobia lomelli* beds).
12. Porphyrite dyke.
13. *Spiriferina* beds—claystones.

The general facies of the Trias in Nelson and southern Otago exhibits a harmony that seems remarkable considering the great distance which separates the localities. Near the base of the formation in each place occur claystones with *Halobia* and *Spiriferina*, and in both places the Trias formation is closed by an *Athyris* horizon, followed conformably by a great series of claystones and sandstones. In Otago the formation conformably overlying the Trias series is known as the Mataura formation, to which a Jurassic age has been ascribed by Sir James Hector and Captain Hutton.

The natural inference to be drawn from the stratigraphical evidence is that the Maitai formation of Nelson must be correlated with the Mataura series of Hutton.

The *Athyris* bed at the top of the series contains thousands of finely preserved *Athyris* and a few *Spiriferina* (*Rastelligera* of Hector). The *Productus* of the so-called *Productus* formation of Mr. McKay at Nugget Point* was found on examination to be a *Spiriferina*.

As there is no reason to believe that the Trias formation in both Otago and Nelson has been overturned, we must conclude, from the stratigraphical and palæontological evidence, that the so-called Permian beds of Mr. McKay in Eighty-eight Valley occur at the top of the formation, and are the horizontal equivalents of the limestone in the Wairoa Gorge.

The characteristic fossil of the Maitai formation in Nelson is *Inoceramus*, which has been found in many places in the lower horizons of that formation on both sides of the great synclinal fold. This form occurs sparingly in the limestone at the base of the formation (*i.e.*, top of the Trias), but is found in great abundance in slaty claystones about 100 ft. above the Maitai limestone in the Maitai Valley and Dun Mountain sections.

I will now review the palæontological evidence bearing on the correlation of the highest fossiliferous zone in Well's Creek with the highest zone in the Shaw Bay section. I have already shown that stratigraphically they both occupy the same relation to the underlying *Mytilus* beds.

Among the *Brachiopoda* from Well's Creek there are two very characteristic genera—namely, a *Spiriferina* with singular comb-like dentition along the hinge-line, and an unusual form of *Athyris*, represented by two species the general features of which have already been described. The *Spiriferina* is the *Rastelligera* of Hector, while the *Athyris* is probably the *Clavigera* of the same author.†

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* Reps. Geol. Expl., 1873–74, p. 63.

† Trans. N.Z. Inst., vol. xi., 1878, p. 538.

The *Athyris* bed at the close of the Trias at Shaw Bay contains both *Rastelligera* and *Clavigera*, the latter in great abundance and in a fine state of preservation. The two species of *Clavigera (Athyris)* which occur in Well's Creek horizon are both represented at Shaw Bay.

The sub-genera *Rastelligera* and *Clavigera* are so distinctive in structure and widely distributed that they are of the highest value for the identification of Trias rocks wherever they occur in New Zealand. In my examination of the Trias in Nelson, Nugget Point, and Hokonui Hills I found them only in the highest fossiliferous horizon.

The Director of the Geological Survey, in his "Outlines of New Zealand Geology," 1886, states that *Rastelligera* occurs in the Otapiri and Wairoa series—that is, in both the Upper and Middle Trias. If this is the case *Rastelligera* has no zonal value. But I can find no reference in the Geological Reports to its occurrence below the Otapiri series except at Well's Creek, where the theory of inversion of the Triassic system suggested by Mr. McKay makes the *Clavigera* beds of the Otapiri series appear to be at the base of the Trias.

The genus *Clavigera*, so far as I have been able to discover, occurs only in the highest marine horizon of the Trias, and, having a definite age-limit, it assumes a zonal value. Hence its occurrence in a group of beds in Shaw Bay, in Otago, and in Well's Creek, in Nelson, tends to indicate the correlative age of these distant beds. But the Shaw Bay *Clavigera* beds overlie the *Mytilus* beds, therefore the *Clavigera* beds in Well's Creek should also overlie the *Mytilus* beds, and I have already shown that they do so.

Thus in both districts the stratigraphical and palæontological evidence clearly proves the superior position of Mr. McKay's so-called Permian beds in Well's Creek, and supports the correlation of the conformably overlying Maitai formation in Nelson with the conformably overlying Mataura formation in southern Otago.

An examination of the geological structure of the region between Nugget Point, Waikawa, and Mataura has confirmed me in the belief that the Mataura and Maitai formations of Sir James Hector represent the same series of beds. Both formations follow the Upper Trias conformably, and both consist of a great succession of slaty shales and sandstones singularly free from organic remains. The Maitai rocks contain *Inoceramus*, annelid-markings, and indistinct plant-remains; the Mataura series *Inoceramus*, annelid-markings, and plant-remains.

As the Carboniferous age of the Maitai formation can no longer be maintained, and since the term "Maitai" has grown almost synonymous with "Carboniferous," to avoid

confusion it would, I think, be preferable to drop the term "Maitai" and adopt the name "Mataura" for all rocks of Jurassic age throughout the colony.

Captain Hutton, in his report of 1873, referred the Maitai formation to the Jurassic system; and now, after a lapse of thirty years, it is necessary for me to bring it back to the position then assigned to it. The Carboniferous age of the Maitai rocks imposed many insoluble problems on the geology of New Zealand. The removal of the Maitai formation to its natural position in the Jurassic now paves the way for a systematic subdivision of the Lower Mesozoic rocks of New Zealand.

Conditions of Deposition of the Nelson Trias.

The presence of plant-remains and of *Mytilus* in the finer sediments, and of *Patella* and saurian bones in the coarser sandstones and conglomerates, points to a prevalence of shallow-water conditions of deposition from the beginning to the end of the Trias period in the Nelson basin.*

Mytilus is essentially a littoral shell. In some horizons it occurs in millions, and in a condition of preservation that clearly shows that the shells were buried in the sediments accumulating around the places where their owners had lived. It is therefore certain that the old marine littoral of the Palæozoic land-surface on the shores of which these *Mytilus* deposits formed was where these fossils now abound—that is, along the southern boundary of the Waimea Plain.

The shallow-water character of the fossil shells and the alternating marine muds and river-detritus indicate that the local conditions of deposition were fluvio-marine, or, at any rate, of such a nature that during abnormal floods, or through the formation of shoals causing a diversion of the ordinary currents, river-detritus became mixed with or spread over the finer marine sediments.

Having shown that the southern limit of the present Waimea Plain at one time coincided with the northern limit of the Nelson Triassic basin, our inquiry naturally leads us to an investigation of the character of the old Palæozoic land-surface whose erosion yielded the material for the Trias formed on its shores.

We have already found that the coarser sandstones and conglomerates are principally composed of diorites, granites, felsites, and quartzose material, none of which occurs *in situ* as a land-surface in the vicinity of Nelson. The nearest granite-area lies to the north-west along the flanks of Mount Arthur range and lower course of the Motueka River. In that

* An interesting petrological description by Dr. Marshall of material from the upper granite conglomerate will be found in Article XXXVI.

region the granite and a great variety of related crystalline rocks are associated with Silurian slates, schists, quartzite, and limestone, which are in places richly fossiliferous.

We must therefore conclude that an extension of the Mount Arthur system, with its associated granites, formed the old littoral of the Nelson basin, and now forms the floor of the Waimea Plain, Moutere gravel hills, and Motueka Valley.

The open Triassic sea extended southward into Marlborough, and in that direction the pelagic sediments would be finer and organic remains rarer than along the shores of the Nelson basin.

General Conclusions.

Summarising the results recorded in the preceding pages, we find (*a*) that the Trias rocks everywhere dip below the Maitai formation; (*b*) that the Maitai formation is principally characterized by the presence of the Secondary genus *Inoceramus;* and (*c*) that the Trias contains such characteristic Lower Mesozoic forms as *Halobia lommeli* and *Monotis salinaria.*

The stratigraphical evidence alone seems amply conclusive of the subsequent date of the Maitais; but, setting this aside, it seems impossible for any student of geology to seriously maintain a Carboniferous age for a formation characterized by such a truly Mesozoic genus as *Inoceramus.*

The Maitai formation, although typically developed in the neighbourhood of Nelson, is one of the most important rock-formations in New Zealand—its importance lying in the fact that it is one of our principal mountain-builders.

Having shown it to be of subsequent date to the Trias has a wider significance than its local relationships might indicate. The Maitai formation possesses the closest stratigraphical connection with the Trias not only in Nelson, but throughout New Zealand. Where one is present the other is seldom, perhaps never, absent. The two formations form one great stratigraphical system, and are so closely associated in the structural features of the country that a definition of the geographical limits of the one must always include that of the other.

Rocks belonging to the Jurassic system, in association with those of the Trias, form the greater portion of the Tararua, Ruahine, and Kaimanawa Mountains in the North Island; while outlying patches occur in the Upper Mokau, at Kawhia, Raglan, Waikato Heads, Kaipara, and Rodney districts, in the Province of Auckland. And we have no reason to assume a greater age for the slaty shales, sandstones, and greywackes which form the floor of the Hauraki Peninsula.

In the South Island this great Juro-triassic or Juro-

permian system composes the broken mountain-chain dividing Nelson from Marlborough, and its western and southern continuation the St. Arnaud and Spencer Mountains, the Kaikouras, and the greater part of the Southern Alps and subsidiary ranges in Canterbury, which are everywhere distinguished by great slopes of moving shingle.

From Canterbury it stretches into Otago, where it forms a portion of the Kurow Mountains and the high rugged chains which extend southward to central Otago and westward to the sources of the Ahuriri River, reaching even to the main divide.

This system also comprises the rocks forming the Hokonui, Takitimu, and Longwood Ranges; and occupies the area lying between the lower Clutha and Waikawa. The shales, sandstones, and limestones of the Blue Mountains, bounding the north side of the Shag Valley, are in all probability an extension of this system from the direction of Mount Ida.

From the foregoing it will be seen that practically all the rocks throughout New Zealand to which a Carboniferous age had previously been ascribed are now included in the Jurotriassic system of Nelson and Nugget Point, in Otago.

There is, however, still some doubt as to the geological position of the gold-bearing rocks at Reefton, which consist of slaty shales and sandstones, often much crushed, folded, and altered. In Murray Creek, and elsewhere in the Inangahua Valley, the Reefton rocks rest unconformably on a highly denuded surface of grey quartzites, slates, and limestone. The slates and limestone contain a rich marine fauna, including *Orthis*, *Strophomena*, *Trilobites*, and other Lower Palæozoic genera. Mr. Cox referred these rocks to the Lower Devonian or Upper Silurian, but Sir James Hector, in his classification of 1887,* placed them in the Upper Devonian.†

The Baton series, like the Reefton series, consists of a great thickness of grey quartzite and slates passing into limestone. The slates contain a large assemblage of marine genera, including a number that appear to be identical with forms found in the Reefton slates. In the above classification the Baton series is referred to the Upper Silurian; but, whether the Reefton rocks are Devonian or Silurian, they afford no clue to the age of the gold-bearing series.

In a paper on the Permo-carboniferous rocks of North Otago I have described the discovery of Permo-carboniferous fossils in the upper part of Hector's Kakanui (Walter and

* Reps. Geol. Expl., 1874–76, p. 63.
† Reps. Geol. Expl., 1886–87, Appendix, p. 256.

Cecil Peak series) formation, thus clearly disproving the Devonian age hitherto ascribed to those rocks.

By correlating the Reefton quartzite series with the Mount Arthur system, which seems the only reasonable and consistent course to follow, we are left without a representative of Devonian age in New Zealand; and the Maitai formation having been shown to be Jurassic, and not Carboniferous, it seems probable that New Zealand is also without a formation truly representative of the Carboniferous period of Europe.

With respect to the age of the Reefton gold-bearing formation, there now remain two courses open to us. We can either consider it an entirely distinct formation and refer it to the Devonian or Carboniferous, or we can refer it to the Mount Mary series in North Otago, to which I have ascribed a Permo-carboniferous age.

The Reefton rocks were first correlated with the Maitai formation of supposed Carboniferous by Mr. Cox as far back as 1875.* They were described by him as resting unconformably on fossiliferous rocks which were referred to the Lower Devonian or Upper Silurian. It seemed, therefore, but natural to refer them to the Carboniferous, and in doing so Mr. Cox had doubtless in his mind the marked unconformity which existed between them and the underlying formation—an unconformity noticed by Sir James Hector in 1873.†

Mr. McKay, in his report on Inangahua County in 1882, followed Mr. Cox in correlating the Reefton gold-bearing rocks with the Maitai formation; but when we examine the grounds upon which this conclusion was based we find the evidence not altogether satisfactory or conclusive. Discussing the age of these rocks, he says, "There is but little resemblance between the Reefton auriferous series and the Permian or Trias rocks of New Zealand, and, as shown, not much with the Te Anau formation as developed nearest to Reefton; so that, in a word, the auriferous series of Reefton can be the equivalent of no other than the Maitai formation."‡

Although I have shown the Maitai formation to be Jurassic, it does not necessarily follow that the Reefton gold-bearing rocks are not Carboniferous, as originally indicated by Mr. Cox. On the other hand, there is nothing to justify the conclusion that they are a separate formation; and until something more definite is known about them I will refer them to the Mount Mary formation of Permo-carboniferous age.

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* Reps. Geol. Expl., 1874–76, p. 77.
† Reps. Geol. Expl., 1872–74, p. 87.
‡ Reps. Geol. Expl., 1882, p. 132.

Besides the Reefton rocks, I think it more than probable that the aphanitic sandstones, breccias, and slates described by Mr. McKay as extending from south of the Greenstone, on the west side of Lake Wakatipu, northward to Lake Harris, and ascribed by him to the Maitai and Te Anau series, in reality belong to the Mount Mary formation.* I also think that the continuation of the same rocks northward to Cascade River, behind Big Bay, described by me as Maitai or Te Anau, should now be included in the Mount Mary formation.†

Generally speaking, it may be said that all the rocks ascribed by the Geological Survey to the Carboniferous system are Jurassic or Triassic, excepting perhaps the gold-bearing rocks at Reefton and the so-called Maitais in the mountainous country lying west and north of Lake Wakatipu.

DESCRIPTION OF PLATES XXXIII. AND XXXIV.

PLATE XXXIII.—SECTION ALONG WELL'S CREEK, EIGHTY-EIGHT VALLEY.

1. *Halobia* and *Spiriferina* beds.
2. Claystones.
3. Lower granite conglomerate.
4. Gritty sandstone, with *Spirigera*, &c.
5. *Mytilus* sandstone.
6. Claystones and sandstones.
7. Claystones, with *Mytilus*.
8. *Pentacrinus* and corals in grits and claystones.
9. Upper granite conglomerate.
10. *Athyris* calcareous pebbly sandstone.
11. Maitai sandstones and claystones.
12. Pliocene gravels, Waimea Downs.

F. Fault.

PLATE XXXIV.—SECTION FROM WAIMEA PLAINS TO WAIROA GORGE AND UPPER RODING RIVER.

A. Waimea Plain.
B. Mount Heslington.
C. Wairoa Gorge.
1. Lower Tertiaries.
2. Serpentine belt.
3. *Halobia* and *Spiriferina* beds.
4. Lower granite conglomerate.
5. Upper conglomerate.
6. Maitai limestone.
7. Maitai shales and sandstones.

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* Reps. Geol. Expl., 1879–80, pp. 140–42.
† Reps. Geol. Expl., 1886–87, p. 132.

Art. XXXIV. — *On the Discovery of Permo-carboniferous Rocks at Mount Mary, North Otago.*

By Professor James Park, F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th October, 1903.*]

Plates XXXV. and XXXVI.

In connection with my examination of the Lower Mesozoic rocks of New Zealand I deemed it of the highest importance to discover, if it were possible, the source of certain fossiliferous boulders found in the terrace drifts on the south side of the Waitaki River by Mr. A. McKay in the course of his geological survey of Waitaki County in the summer of 1880.*

Mr. McKay made a collection of fossils from the boulders. The fossils, he considered, indicated a Lower Trias or Permian age. He traced the boulders up the course of the Awahokomo to the foot of the Kurow Mountains, which he found were composed at that place of phyllites and altered sandstone, at that time believed to belong to the Kakanui or Walter and Cecil Peak series of supposed Devonian age.

On reaching the "Kurow schists" Mr. McKay desisted in the search, conceiving that the fossiliferous boulders could not have been derived from that formation, and subsequently, when discussing the probable source of the fossiliferous boulders, hazarded the opinion that they had been transported from some part of South Canterbury by the agency of glacier-ice.†

Thus the matter stood from 1880 till the present year. Early in March of this year I visited the Waitaki Valley, making my headquarters at Kurow. I searched the river-terraces between Kurow and Awahokomo, and also the lower courses of the Big and Little Awakino.

I found, as reported by Mr. McKay, that the greatest number of fossiliferous boulders occurred in the bed of the Awahokomo, and subsequently I confined my search to the course of the stream. Boulders containing fossils were fairly abundant in the first three miles—that is, up to the point where the stream cuts into the schistose rocks. Beyond that point, as found by Mr. McKay, fossiliferous boulders seemed to be absent, and for a time I was uncertain which course to pursue. After a time I decided to continue up the bed of the stream. For some distance I met with no success, but after proceeding less than half a mile I began to again find traces of fossiliferous boulders, but only at wide intervals. The traces

* Reps. Geol. Expl., 1881, p. 77.

† *L.c.*, p. 77.

occurred so sparingly that I was compelled to search all the side branches of the main stream lest I should pass the parent rock to the right or left. This work occupied much time, but satisfied me that I was on the right track in following up the main stream.

I had now reached back to the flanks of Mount Mary. The descent of the stream was rapid, and, instead of a wide boulder-strewn bed, the course of the stream was a narrow rock-cut channel. The elevation was over 3,000 ft., and I was now convinced that I had reached a position beyond all possible influence of ancient glacier-ice from South Canterbury. Huge masses of fossiliferous rock occurred in the channel at intervals, and at the big waterfall, at 4,000 ft. above the sea, I found indistinct traces of fossils in highly indurated greenish-grey altered sandstones. Blocks of fossiliferous rock were now more plentiful, and, having the basin at the source of the stream immediately above me, I was at last satisfied that the fossiliferous outcrop was not far distant.

The evening was now approaching, and, being alone and far from my headquarters, I was compelled to retrace my steps without visiting the main outcrop, which I afterwards found was within view of the waterfall.

Three weeks later I again visited the Waitaki, on this occasion accompanied by Mr. A. Hamilton, who was greatly interested in the discovery.

We directed our way at once to the big waterfall near the source of the Awahokomo, and, after a stiff scramble, at a height of 5,160 ft. reached the main outcrop from which the fossiliferous boulders had been shed.

The outcrop lies on the left or west side of the basin at the source of the stream, at some 500 ft. below the summit of the range. Fossils were found in three zones in a thickness of 50 ft. of strata. The two lower zones are altered slaty shales and the upper a bed of conglomerate. In the two lower zones fossils are very abundant and generally well preserved. The *Athyris, Spirifera,* and *Spiriferina* are especially large and fine, although many specimens are much crushed and distorted.

The fossiliferous rocks are distinctly altered and closely associated with altered sandstones, and with slates which are almost identical with the slates at Otepopo. They follow the phyllites, quartzites, and altered rocks of the "Kurow schists" in a direct stratigraphical succession.

The strike of the strata from the foot of the range to the summit is N.W.–S.E., and the dip S.W. Excepting in one or two places, where the strata exhibit minor folds or corrugations, the general strike and dip are remarkably uniform throughout, and in the rock-cut course of the Awahokomo the

succession and relationship of the different rocks are seen to great advantage.

At the foot of the mountains the dip of the rocks is very high, but ascending the Awahokomo it gradually decreases, and at the foot of Mount Mary is as low as 35°. Ascending Mount Mary the dip gradually increases, and at the fossiliferous outcrop is about 60°.

The total thickness of strata exposed in this section is not less than 10,000 ft. The lowest rocks are pale-grey and blue phyllites, generally much crushed and often drossy. The phyllites are followed by thin-bedded quartzite and altered claystone and a great thickness of pale-green altered greywacke and breccia, the former occurring sometimes in thin and sometimes in thick bands, and frequently seamed with a network of small quartz veins.

Above the upper forks of the Awahokomo blue silky slates are interlaminated with thin layers of quartz, which vary from a mere thread to 4 in. thick.

Above an altitude of 3,000 ft. altered argillaceous rocks become less abundant. At 3,200 ft. there is a considerable development of thin-banded siliceous sandstone, almost quartzite, and dark-blue claystone, occurring in thin laminæ varying from 1 in. to 2 in. thick.

From this onward to the summit of Mount Mary the bands of sandstone, greywacke, and breccia become more massive and less altered, and here we meet a few narrow bands of red and green slaty shale which are often streaked with jasperoid segregations. The pale-green aphanitic sandstones and greywacke, which are so prominent in the lower part of the succession, are now absent. The sandstone bands are coarse and gritty, but the argillaceous beds, lying between two bands of sandstone or greywacke, are still considerably altered.

The rocks just described are highly altered and schistose near the bottom of the series, and become gradually less and less altered in passing upward towards the top of the sequence. This is partly, but not altogether, explained by the circumstance that the more easily altered argillaceous strata predominate in the lower part, and the more siliceous and consequently less easily altered rocks in the middle and upper parts.

The rocks in the immediate neighbourhood of the main fossiliferous outcrop are as follows in ascending order :—

(*a.*) Grey indurated sandstones, often coarse and gritty.

(*b.*) Blue fissile slates, like slates at Otepopo.

(*c.*) Slaty and flaggy claystones slightly micaceous, con-

taining two zones of fossils about 20 ft. apart, the lower 6 ft. thick and the upper 3 ft. thick.

(*d.*) Bed of pebbly conglomerate and sandstone varying from 3 ft. to 6 ft. thick, and separated from the upper fossiliferous zone by several feet of flaggy claystone.

(*e.*) Grey indurated sandstones, and flaggy claystones.

Fossils are very abundant in the two lower zones, and, although many are flattened and deformed through the alteration which the rocks have suffered, distinct and well-preserved casts are numerous, and easily broken out.

Among the genera identified in a small collection were *Spirifera* (two sp.), *Spiriferina* (two sp.), *Athyris*, *Epithyris*, *Rhynchonella*, *Edmondia*(?), *Allerisma*(?), *Schizodus*, *Ostrea*, *Turbo*, *Patella*, *Pleurotomaria*, and a nautiloid shell.

Captain Hutton examined the collection in Dunedin, and subsequently, after looking over the Permo-carboniferous fossils of New South Wales in the Canterbury Museum, informed me that he was pretty sure the Mount Mary collection included *Spirifera vespertilio*, G. Sow., *Spirifera subradiata*, Sow., *Eurydesma*, Morris, and *Platychisma*—forms characteristic of the Permo-carboniferous of New South Wales.*

Mr. W. S. Dun, of Sydney Museum, to whom a small collection of these fossils was sent, in a letter to Mr. A. Hamilton confirmed the identification of the spirifers made by Captain Hutton.

A collection of these fossils is now in the hands of Professor Boehm, of Frieburg, for identification and description. His determinations will be awaited with much interest by students of New Zealand geology.

Subdivision and Correlation.

The grey phyllites, banded quartzites, aphanitic sandstones, and greywacke at the base of the succession comprise the "Kurow schists" of McKay, which were rightly referred by that geologist to the Kakanui series of Hector. It has generally been admitted that the Kakanui series of Hector is the equivalent of the Kakanui (Tuamarina) formation of Hutton† and the Waihao formation of Haast.‡

The rocks forming the upper part of the succession correspond closely to the description given of the Kaikoura formation of Hutton§ and the Te Anau series of Hector,

* Hutton, Letter to author, 29th April, 1903.

† Hutton, "Geology of Otago," 1875, p. 32.

‡ Haast, "Geology of Canterbury and Westland," 1879, p. 260.

§ Hutton, "Geology of Otago," 1875, p. 35.

and they occupy the same relative position with respect to the "Kurow schists" that the Te Anau series does to the Kakanui series.

In his "Outlines of New Zealand Geology" Sir James Hector recognised the close association of the Te Anau and Kakanui series, and referred them to the Devonian period, as under :— *

"XIII. Devonian.
"(*a.*) Te Anau series.
"(*b.*) Kakanui series."

In the latest classification of the Geological Survey,† dated the 30th June, 1887, the Kakanui series disappears from the table of formations, and is apparently, but without explanation, included in "XIII. Lower Devonian — Reefton beds," which had no existence in the classification of the previous year ("Outlines of New Zealand Geology," p. 40).

Briefly summarising the foregoing, we find that the highly altered phyllites and quartzites of the lower flanks of the Kurow Mountains are succeeded conformably by the less altered Mount Mary fossiliferous slates and sandstones. The former are included in the Kakanui series of Hector and Hutton, and the latter in the Kaikoura formation of Hutton and Te Anau series of Hector.

I am inclined to agree with the early opinion of Hector and Hutton that the "Kurow schists," notwithstanding that they pass insensibly into the Mount Mary series, are sufficiently distinctive to be separated from the upper series.

For the lower and more altered group of Kurow rocks I propose to revive the old "Kakanui series" of Hector, in which they were originally included. For the upper and less altered group I do not think there is a more appropriate name than Mount Mary series.

The Mount Mary series undoubtedly includes the Te Anau series of the Geological Survey, of supposed Devonian age, but there are several reasons why the name "Te Anau" should be abandoned. In the first place, we have it on the authority of Mr. McKay that the rocks typical of the Te Anau series do not occur at Lake Te Anau; and, further, the Te Anau series has always been difficult to distinguish from rocks supposed to belong to the Maitai series of the Geological Survey.

On the other hand, the rocks at Mount Mary are fossiliferous, and perhaps this is the best reason for attaching the name of that mountain to the new series. The proposed subdivisions of this succession of rocks are as follows :—

* Hector, "Outlines of New Zealand Geology," 1886, p. 40.
† Reps. Geol. Expl., 1886-87, Appendix, p. 256.

Permo-carboniferous—

Mount Mary series.

(Syn.: Te Anau series, Hector; Kaikoura formation Hutton; Lower part Mount Torlesse formation, Haast.)

Carboniferous—

Kakanui series.

(Syn.: Kakanui series, Hector and Hutton; Tuamarina formation, Hutton; and Waihao formation, Haast.)

Relations to Adjoining Rock-formations.

The Waitaki River, between the Kurow and Awahokomo, runs along the axis of an anticline of claystones and sandstones, in which Mr. McKay discovered numerous remains of *Inoceramus*, including an almost perfect example found near the mouth of the Hakataramea.*

Mr. McKay shows these rocks to be unconformable to the altered Kurow rocks, and refers them to the Maitai series of the Geological Survey, of supposed Carboniferous age.

As the "Kurow schists" have been shown to be associated with rocks of Permo-carboniferous age, it necessarily follows that the Waitaki Valley rocks, which overlie these unconformably, must be of subsequent date; and the presence of the Secondary genus *Inoceramus* clearly indicates that they must be referred to the Jurassic system, a position quite in harmony with my conclusion respecting the Jurassic age of the Maitai series in Nelson.

The Mount Mary series fills a gap in the New Zealand geological record, and, furthermore, furnishes for the first time reliable data by means of which the age of the Kurow phyllites can be ascertained.

The classification which my investigation of the Lower Mesozoic and Upper Palæozoic rocks in the past three years has led me to adopt is as follows:—

Jurassic—Mataura series.

Triassic—Shaw Bay series—

(*a.*) *Athyris* (or *Clavigera*) beds.
(*b.*) *Mytilus* and *Monotis* beds.
(*c.*) *Trigonia* beds.
(*d.*) *Halobia lommeli* beds.
(*e.*) *Spiriferina* beds.
(*f.*) Nugget Point plant beds.

Permo-carboniferous—Mount Mary series.

Carboniferous—Kakanui series.

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* Reps. Geol. Expl., 1881, p. 78.

EXPLANATION OF PLATES XXXV. AND XXXVI.

Plate XXXV.—Section from Waitaki River to Mount Mary.

Reference.

(*a.*) Claystones and sandstones.
(*b.*) Sandstone conglomerate.
(*c.*) Phyllites.
(*d.*) Banded phyllite and quartzite.
(*e.*) Altered sandstones, &c.
(*f.*) Sandstones, gritstones, &c.
(*g.*) Slates and flaggy sandstones.
(*i.*) Grey sandstones, and flaggy claystones.

Plate XXXVI.—Plan of Part of Waitaki Valley, showing Position of Mount Mary.

Art. XXXV.—*The Northern Wairoa.*

By E. K. Mulgan, M.A.

[*Read before the Auckland Institute, 21st September, 1903.*]

The Northern Wairoa is in several respects a wonderful river. Rising in a narrow peninsula, it is wholly confined to a relatively small extent of country. The entire catchment-area, indeed, does not measure more than fifty miles by forty miles, and yet this gathering-ground is able to furnish sufficient water to supply a river which is navigable for the largest ships for upwards of fifty miles, and for smaller craft for nearly double that distance. Can any other river in New Zealand show a similar record? Throughout the lower part of its course the fall is so slight that the influence of the tide is felt beyond the "Junction" (*i.e.*, junction of Mangakahia and Wairua Rivers), a distance of more than a hundred miles from the Kaipara Heads.

The term "Northern Wairoa" is used in the title of this paper in a somewhat wider sense than that in which it is generally employed, this name properly belonging to that portion of the river between the Kaipara Heads and the "Junction."

The streams forming its head-waters are known as the Mangakahia and Wairua (the latter in its upper reaches receiving the name of the Waiotu), both of which drain the northern slopes of the basin, the former to the west and the latter to the east. The two streams gradually converge, and finally meet at what is known as the "Junction." Other tributaries are the Kaihu and Tangowahine, flowing south, and the Mangonui, draining the basin to the south-east.

The stream known in its lower course as the Wairua rises a few miles to the east of Kawakawa, and not far from the upper waters of the Bay of Islands. From here it flows in a

southerly direction, keeping well to the east of the peninsula, and receiving on its way the Whakapara and Mangahahuru Streams, both of which come from the east, and drain the country almost to the seaboard.

The Mangakahia rises on the southern slopes of the watershed separating the Hokianga and Kaipara basins, and, gathering supplies from the northern and eastern slopes of Tutamoe, skirts the Tangowahine range, receives further down the Hikurangi from the north, and finally unites with the Wairua at the Junction.

The Kaihu, which drains the basin to the west, is worthy of note in that it receives supplies from streams some of which rise not far from the source of the Mangakahia, and others almost at the coast. The Kaihu itself, moreover, keeps parallel to the coast until it reaches the Wairoa at Mangawhare.

The Mangonui rises on the western slopes of the hills to the west of Waipu, and, flowing north-west, is joined by another large stream, the Tauraroa. From here its course is first west and then north until the Wairoa is reached.

It will be seen from this that the catchment-area practically includes the whole of the land from coast to coast, and stretches from a line joining the mouth of the Hokianga Harbour and the upper waters of the Bay of Islands as far south as the Kaipara Harbour. That is to say, bearing in mind the configuration of the country, the river-basin comprises the maximum area available. These singular conditions have been made possible by the distribution of the high land. It usually happens that the highest land of a country occurs in the centre, and the lower levels are found near the coast. In the case of the Wairoa basin these conditions, although not entirely reversed, yet are considerably modified. The greater part of the land is high; indeed, nearly the whole of the central portion of the basin consists of broken, bush-clad ranges, some of which reach an elevation of from 1,500 ft. to 2,000 ft. (Tutamoe, the highest peak north of Auckland, has an elevation of 2,576 ft.). These ranges, whose general trend is from north to south, are cut across in many places by narrow valleys, and flanked on either side by low hills running parallel to the seaboard. Thus, the whole of the rainfall on this portion of the peninsula, instead of being carried to the sea by a number of different streams, is collected to furnish the supply for a single river.

The size and configuration of the catchment-area would not in themselves account for the volume of water discharged by the river. A more important factor than either is the rainfall, which in this particular case must reach phenomenal

proportions, seeing that the area over which it is distributed is so small in extent. In point of fact, the rainfall across that portion of the Auckland Peninsula is exceptionally great. The prevailing westerly winds, after their passage over the Tasman Sea, reach the relatively high land heavily laden with moisture, where the inevitable lowering of temperature brings about a constant precipitation of rain. I was unable to obtain reliable statistics touching the rainfall, but several well-known facts pointed to its great abundance. When the surveyors and parties were cutting the track for the road through the Awatuna and Marlborough Settlements they found the ground very damp and soft, and the tree-trunks covered with moss and lichen. The ground was frequently buried to a depth of several feet in moss, and was everywhere saturated with moisture. The men employed on the work suffered much from the wet and damp, some of them being obliged to give up their employment in consequence. Then, again, the settlers experience great difficulty in burning off the bush. "It will not burn," they say — a statement to which the half-burnt logs and ill-cleared land bear ample witness. One cannot help noticing the readiness with which the scrub (chiefly makomako—*Aristotelia racemosa*) comes up in the clearings, and the small extent of land which is really freed from bush, as also the extreme moistness of the land itself. It seems unnatural to find soft boggy soil at such a high elevation— to find it, in fact, on hilltops.

That there is very considerable rainfall cannot be doubted, and this, added to the size and configuration of the catchment-area, accounts for the dimensions of the river, which at first sight would appear out of all proportion to the conditions under which it exists.

The fall of the river from the Junction to the sea is very slight—only a few feet—for the effects of the tide are felt considerably beyond that point This implies that the velocity of the stream itself is small, hence we would expect to find, as is actually the case, a wide flat-bottomed valley filled with detritus.

From the Junction to the sea the Wairoa has lost the power of vertical erosion. The banks of the river, however, are soft, and the load of sand and mud carried by the water is very great, conditions highly favourable for lateral erosion, hence one is not surprised to find that the river has cut for itself a very winding channel. It is well to remember, in considering the work done by rivers, that running water is only the motive power, and that the instrument which really does the work is the sand and mud carried along by the water. A perfectly clear stream running over a bed of sand and pebbles which do not move is doing no work at all; it is only

when its waters are loaded with sediment that it becomes such a powerful agent of erosion.

In the course of the Wairoa from the Junction seawards a number of very interesting loops occur, any one of which would furnish a profitable subject for investigation, and well repay the trouble spent in unravelling its history. Take, for instance, that large loop below the junction of the Mongonui Stream. In this case the river, flowing north-west, was deflected at Te Pango by an elevation which, although slight, was sufficient to give direction to the current. Meantime its waters spread out over the low ground on what is now its left bank, where, the current being checked, deposition took place, gradually bringing the depressed area up to its present level. This area, which must have been a large one, grew towards the north, and in so doing gradually pushed the river-bed in the same direction, until the process was arrested by the low range of hills along the right bank, and the river was confined to its present channel. The net result has been the formation of a large flat nearly circular in shape with a series of low hills running across its narrow end.

The power of the stream to erode laterally is well seen in several places, notably at Dargaville. Here the line of greatest velocity has impinged against the right bank, cutting into it for a considerable distance. One is surprised at first that it has not gone further and cut back as far as the high ground behind Mangawhare. But the fact is that the process of erosion here has not been long in operation. It was not until the growth of the opposite bank—to be explained further on—forced the current into its present course that the banks on the Dargaville side began to disappear. The presence of the Kaihu Stream no doubt brought about at an earlier time the deposits of the Dargaville and Mangawhare flats.

Erosion and deposition are both going on; indeed, in a river of the kind where the fall is not great this is inevitable. At Dargaville, for instance, if the right bank is disappearing, the left bank is gradually being pushed out into the stream. The erosion on the Dargaville side is now arrested to a large extent by heaps of stones placed at intervals along the bank. The effect of this has been to narrow the channel, and hence to increase the velocity and erosive power of the current, with the result that a sandbank of considerable size, nearly opposite Mangawhare, has lately disappeared. The appearance of the banks, too, is very characteristic. A deep channel runs pretty close to the right bank, where, moreover, the ground is hard and presents a vertical face to the water even at high tide. The left bank, on the other hand, consists of a low shelving deposit of mud.

One of the first things that strikes an observer is the

extreme turbidity of the water, a turbidity, moreover, from which it is never free. The load of mud carried is very great—indeed, it is difficult to conceive of its being increased to any large extent. The particles of which the mud consists are extremely small, so much so that a good deal of the deposit is carried far out into the Kaipara Harbour before coming to rest on the sea-floor.

That an immense quantity of detritus has been carried down by the river is abundantly proved by the deposits of alluvium along its banks, and the source of supply may no doubt be looked for in the higher ground of the river-basin, where the low ranges consist partly of sedimentary and partly of volcanic rock. The outcrops of these are much decomposed and weathered, and the flanks of the hills are steep, conditions favourable for the removal of a disintegrated surface. Much of the country, however, is covered with bush, which serves to bind together the surface-soil and prevent its being washed away. It is not surprising, therefore, that the tributary streams draining the area in question do not show any noticeable turbidity—indeed, they present the appearance of clear running brooks—and yet the waters of the Wairoa are always heavily laden with mud. Clearly, then, the present supply of detritus carried by the river is not directly derived from its tributaries, but is largely the result of lateral erosion. Some of it is carried down and spread out on the harbour-floor, but much of it is washed backwards and forwards by the tide and current before being finally deposited where the banks are growing.

So free from suspended impurities are most of the tributary streams that the question arises, Would a supply of material such as now finds its way into the river be sufficient to furnish the deposits of alluvium found in the valley; in other words, have conditions become greatly modified since the deposits were laid down? There do not seem to be any strong reasons for supposing that they have, for the drainage-area is large enough to furnish all necessary supplies if only time were allowed and the river-valley where the deposits occur is relatively small. Still, there may have been a time when deposit, owing to altered conditions, was more rapid than now—when, for instance, a good deal of the country at present bush-clad was comparatively bare, and when in consequence the weathered surface was readily and easily swept away. The country may then have stood at a much higher level, which in itself would account for a more scanty vegetation, and the reduction in height may have been brought about partly by erosive agencies and partly by depression. To reach a period when such conditions prevailed one would have to go back a considerable time, if

we may judge from the growth of some of the larger of the forest-trees, which indicate an age of between two and three thousand years—perhaps more.

The left bank of the river near its mouth consists of an immense tract of flat land containing several thousand acres, and known as the Tokatoka Swamp, the whole of which, no doubt, has been carried down and deposited by the river. The swamp is on the north-eastern side of the Kaipara Harbour, and the prevailing winds are south-westerly. The effect of these has been to cause the water, with its load of mud, to spread out towards the opposite shores. In this way the north-eastern side was gradually filled up and converted into land. The process of deposit has by no means stopped. The southern portion of the swamp gradually becomes lower until it ends in a wide mud-flat covered with mangroves, where a constant detrital deposit is going on, with the result that the bank is being pushed out further and further into the harbour. Owing to the continual deposit the river-channel is now confined to the shore-line along the western side.

The land of which the swamp consists is extremely fertile, and has given magnificent returns to those who have been fortunate enough to secure it. A good deal of work in draining and surveying has been done by the Government, and already several blocks have been disposed of by ballot. Some difficulty was at first experienced in obtaining water, but this has since been overcome by sinking artesian wells. The result of the borings put down are not without interest as throwing light on the origin of the deposit and the rate at which it was laid down. For the following tables giving an account of the borings at Raupo I am indebted to Mr. R. F. Baff, who personally superintended and directed the operations. It may be explained that Raupo is the name given to that portion of the swamp already settled.

Details of Borings.

No. 1, at Raupo.	Ft.
50 ft. soft clay or mud (blue)	50
45 ft. soft sands and mud	95
7 ft. hard clay light-grey in colour	102
33 ft. sandy clay	135
19 ft. quicksand. (Dribble of water, drop at a time, rises 2 ft. 6 in. above ground: tried pump—no better) ...	154
22 ft. soft sandy mud	176
19 ft. grey clay, changing to brown, with woody particles	195
17 ft. sharp sand. (Good flow of water, which rises 12 ft. above surface of ground, and at 3 ft. above ground gives 20 gallons per minute, or 28,800 gallons per twenty-four hours)	212

No. 2, about two miles and a half from Raupo.

	Ft.
10 ft. clay or mud	10
52 ft. soft sand and shell	62
58 ft. clay or mud	*120
12 ft. coarse sand. (Water rising near surface) ...	132
18 ft. clay (blue)	150
8 ft. sand, same as before	158
18 ft. soft sandy papa (blue), varies in thickness ...	176
8 ft. hard pure papa. (Stopped sinking. Drew pipes back to 120 ft. (see * above). Water rises 12 ft. above ground, gives 3,000 gallons per twenty-four hours—clean water free from salt)	184

No. 3, about three miles south of Raupo.

10 ft. soft clay	10
80 ft. dark quicksand	90
6 ft. hard clay	96
17 ft. white sand (sharp)	113
56 ft. brown and blue clay	169
41 ft. fine white sand, with flow at 2 ft. above surface—good strong flow, gives 14,400 gallons per twenty-four hours clean and good water	210

At Mangawhare the boring operations, which were carried on with the same object as those at Raupo, and which, moreover, were not successful, in that the supply of water obtained was insufficient, disclosed the following details: Beginning at the surface, the pipes passed through 80 ft. soft wet river-mud, 50 ft. fairly hard argillaceous limestone, 80 ft. calcareous marl (papa). There were no traces of marine or fresh-water organisms found in these (Mangawhare) deposits.

The papa rock referred to both here and at Raupo is an indurated calcareous marl of presumably Cretaceo-tertiary age, which outcrops at various places across this portion of the peninsula. Taking this as the basement rock, we have in the case of the Tokatoka Swamp a deposit of upwards of 200 ft. of sea-borne and river-borne sediment; indeed, it is highly probable that the depth of this deposit in places is not far short of 300 ft., an immense depth when it is remembered that it occurs in a relatively small land-locked harbour. The material passed through in the borings, however, is not altogether the product of the river. The eastern limit of the sandstone series forming the land between the river and the coast no doubt extended at one time as far as the flanks of the hills to the east of the Kaipara Harbour. The upper members have been removed by denudation, but the lower beds still underlie the swamp-deposits. An examination of the tables

will show this. Near the surface the borings invariably passed through soft clay or mud, after which the material met with always contained more or less sand. To attribute to the agency of the river the whole of the material passed through in the Tokatoka Swamp borings would be to demand a continuance of conditions under which a gradual subsidence took place with sufficient slowness to enable the river to fill up the depression. This appears to be highly improbable; there is nothing to warrant the supposition, which, moreover, is not required to explain existing conditions. The great depth of river-deposit at Mangawhare (80ft.) is a more difficult matter to account for, and until further evidence is forthcoming we may attribute it to some local depression.

It is difficult to arrive at any accurate knowledge as to the rate at which the deposit was laid down. As affording some guide to this it may be mentioned that two clubs of black-maire (*Olea cunninghamii*)—the kind used by the natives in crushing fern-root—were found about 13 ft. from the surface by some men whilst cutting a drain. It is not at all likely that these clubs were buried to that depth by the natives; it is much more probable that they were dropped into the waters of the old swamp or harbour and were gradually covered up. The wood of which they were made would at once sink to the bottom. This is very slender evidence to build on, but if it is to be accepted at all it would go to show that the deposit has been a rapid one, and that the last 13 ft. have been laid down within a period which could not have extended over many generations.

The borings at Mangawhare appear to have gone through nothing but river-mud before reaching fairly hard argillaceous limestone, a rock similar to that which outcrops at Arapohue, Okahu, and other places along the eastern side of the river. The age of this limestone is considerably greater than that of the river-deposit, so it may here be taken as the basement rock. Hence at Mangawhare the depth of alluvium is about 80 ft.; and, as no remains of marine organisms are found, we may conclude that the deposit is of fluviatile origin. This no doubt applies to all of the material forming alluvial flats along the river north of Te Kopuru. It is not improbable that the sea once flowed over the land now known as the Tatarariki Flat, and that the high ground from Te Kopuru south at one time formed part of the western shore-line of the harbour.

On the eastern bank of the river there occur some very remarkable volcanic outcrops, rising through the sedimentary rocks at short intervals and extending for several miles in a line running approximately north and south. The first of these met with is at Maungaraho, evidently the remains of a huge dyke 720 ft. in height and dipping towards the north-

west. Seen from the south it presents a broad surface like that of a wall viewed at right angles to its length; from the north-east or south-west it has the appearance of a wedge, broad below and tapering above. About two miles south of Maungaraho is the Tokatoka Peak, a well-preserved volcanic neck rising through the shales to a height of 580 ft. The base is relatively large, but the summit tapers to a point with an area of a few square yards. In the upper portions well-defined columnar structure is seen; but this disappears some little distance from the top. The rock can be traced to the river, where it forms a low cone-shaped boss. Between the Peak and the boss—known as Cemetery Hill—is a well-marked depression. None of the rock here presents the appearance of a lava-flow, but rather that of the remains of the upper portion of a subterranean reservoir. To the east the volcanic rocks pass under the shale and reappear again about a quarter of a mile further on. The rock here is much weathered, but lying on and showing through the surface are a number of boulders compact and fresh-looking. They consist of a hard close-grained andesite with large well-defined augite crystals. A short distance further on the junction of the shale and volcanic rock can be seen in an old road-cutting. At this point the rock is much decomposed, but the remains of the augite crystals can be plainly seen. About a mile to the south of the Peak the same rocks again outcrop in a low rounded hill, which is evidently a boss. The rocks here cross the river in a south-west direction, reappearing in a well-defined conical hill rising through the river-deposit, known as the "Green Hill," and consisting of a hard-grained andesite very similar to the boulders found to the east of the Peak. Much of the rock at this exposure shows but little sign of decomposition, and will in the future furnish valuable material for road-metal. A little more than a mile to the south of this spot another similar outcrop occurs, bare at low tide and a source of much danger to vessels. In the Tokatoka Swamp itself, about a mile and a half back from the landing at Raupo, these rocks again rise to the surface, where quarrying operations are carried on. The rock is broken in a steam-crusher and used for ballasting the railway-line running through the swamp, as well as for spreading on the roads. There is little or no doubt that these outcrops are connected, and have had their origin in some common reservoir.

The land between the Wairoa River and the coast consists for the most part of soft sandstone arranged in horizontal layers, which under the action of the weather crumble into white sand composed in places almost entirely of silica. At the coast the rocks are very soft, and are readily acted on by the atmospheric agents of erosion. Great quantities of the

looser material are washed down by the rain and spread out in the form of fans along the beach. The harder portions then tumble off and are rapidly broken to pieces and carried away by the action of the waves. The work of erosion here must be rapid, for the prevailing westerly winds at times drive in the waves with great fury. This strip of land, extending from the Kaipara Heads to the Maunganui Bluff, and having a width of about seven miles, appears to have its eastern limit along the river. It is evidently the remains of a much larger and higher area which at one time extended westward, and has gradually been reduced to its present size under the action of the weather and the sea. In none of the exposures were any fossils to be seen, but the general appearance of the rocks, their well-defined stratification, and the presence of a band of compressed vegetation some 6 ft. or 8 ft. in thickness outcropping at intervals for miles along the coast remove all grounds for doubt as to their origin. The whole of this area is an immense gumfield, and yet there are no kauri-trees to be seen. The forests which must have covered it have long since disappeared, and the land is now clothed with a stunted growth consisting chiefly of fern, *Leptospermum scoparium*, *Leucopogon fasciculatum*, *L. fraseri*, *Pomaderris elliptica*, *P. filicifolia*, and other plants usually found where these comprise the prevailing vegetation. The kauri seems to thrive best on rugged, broken country where the elevation is considerable. Any pronounced lowering of the general level would bring about the destruction of the trees, and this is apparently what has happened. As the land subsided the forests died out, leaving behind these extensive deposits of gum which of late years have become so valuable. These beds of sandstone no doubt in former times had their eastern extension along the flanks of the hills running north and south on the left bank of the river, and overlay unconformably portions of the older shales of which most of these hills consist. The upper portion of this part of the series has now been completely removed by the river, which in all probability originally flowed along the junction of the older and younger rocks, and hence carried away first those portions forming the eastern extension of the beds.

On the beach at the west coast is found an interesting and valuable burrowing mollusc, *Mesodesma ventricosa*, known locally as the "toheroa." In size it varies greatly, but some of the larger forms measure as much as 6 in. by 3½ in. Its habitat occurs between high- and low-water mark — at least, that is where it is found. When the tide is in it comes to the surface of the sand, and, thrusting out its siphons, obtains the necessary nourishment from the sea-water. As the waves retreat the siphons are withdrawn, and

the animal again buries itself to a depth of from 12 in. to 15 in. This it accomplishes by thrusting from the ventral surface of the anterior end of the shell a powerful wedge-like foot, which it forces into the sand by means of a peculiar wriggling movement. As soon as the foot has penetrated as far as it can reach it is made to contract and drag the animal after it. It is surprising how few of these contractions are required to bury the animal completely, and with what rapidity it disappears. The settlers and natives consider the toheroa a great delicacy, and, as it is easily obtained, great numbers are dug up and used as food. At Mangawhare a tinning-depot has been established, and already a considerable output is disposed of. It is said that the animal is confined to a small portion of the coast reaching from the Murewai Caves to the Maunganui Bluff; but further evidence is necessary before accepting this statement, though, from all accounts, it has not been found in any quantity elsewhere. If it be true that its habitat does not extend beyond this limited range, an extremely interesting subject awaits investigation, for there seems to be no barrier to prevent its spreading all along the ocean-beaches of the northern portion of the Island. Its restricted range may be caused by a food-supply being confined to the area over which it is found, or by the sand in which it burrows being in some way specially fitted for its needs. This last conjecture does not appear to be a likely one, for the sand on the west coast is constantly moving. Another peculiarity is that it is found in patches, these often being separated by considerable distances. An explanation of this may be that the animal lives some distance from the shore, and only leaves the deeper water at breeding-time. Living together in great numbers on special feeding-grounds, the animals may migrate at intervals to shallow water, each migration being shared in by a large number of individuals.*

The Northern Wairoa has long been the seat of a large and important timber industry, the immense kauri and kahikatea forests with which much of the river-basin was clothed furnishing an accessible and readily marketable supply. The kauri forests on the hills along the river and in other places easily reached have long since been removed, and a very few years will see the complete disappearance of the kauri as a timber-producing tree in the Northern Wairoa. The rapid removal of the timber may be attributed

* Since this was written I have learnt that the toheroa occurs along the coast to the north and south of the Raglan Harbour, and to the north of Porirua Bay; but in none of these places is it found in such abundance as on the ocean-beach opposite Dargaville.

partly to its value and partly to the fact that in nearly all cases its conveyance to the mills was a matter of comparative ease. The numerous tributaries of the river, many of them deep, well supplied with a constant flow of water, and reaching far back from the main stream, furnish the best of all waterways for the conveyance of logs. When the natural supply of water is not sufficient to float these they are forced along by driving-dams or hauled out of the bush, either by bullocks or steam-engines. Great ingenuity is brought to bear on the removal of trees from difficult positions—huge logs, weighing many tons, are hauled from the bottoms or sides of steep gullies or lowered from the tops of lofty hills. Timber whose position a few years ago would have rendered it valueless is now worked with profit; indeed, there are few patches of kauri sufficiently inaccessible to be beyond the reach of the axe and the wire rope.

A good deal has been written on the slow growth of the kauri. The following contribution to the literature of this subject by a northern settler may be of interest: "In 1896 a number of trees, measured 7 ft. from the ground, girthed something under 3 ft. 4 in. Ten of these trees, measured under similar conditions in 1901 (five years afterwards), girthed as follows: 3 ft. 5 in., 3 ft. 6 in., 3 ft. 7 in., 3 ft. 8 in., 3 ft. 10 in., 3 ft. 11 in., 4 ft., 4 ft. 1 in., 4 ft. 2 in., 4 ft. 3 in. This would give an average girth of 3 ft. 10 in., and hence an average increase of girth of 6 in. in five years, slightly over 1 in. per annum. These trees were in sheltered positions; in those growing on exposed situations there was no perceptible change."

On the low land bordering the river there is still a great quantity of kahikatea—a valuable timber for some purposes, easily obtained and easily worked. An immense kahikatea forest, estimated to contain between ninety and a hundred million feet of timber, covers the northern and eastern portions of the Tokatoka Swamp. A mill has been erected and is now in full operation at Raupo, where many years of work await the enterprising owners.

Art. XXXVI.—*Notes on a Small Collection of Fossils from Wharekuri, on the Waitaki River, North Otago.*

By A. Hamilton.

[*Read before the Otago Institute, 13th October, 1903.*]

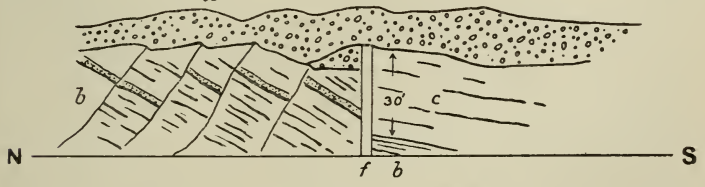
Plates XXXVII. and XXXVIII.

Last Easter I had an opportunity of visiting a portion of the valley of the Waitaki immediately to the north of Kurow, in company with Professor Park, and we spent one day at Wharekuri, as I was anxious to see the locality in which Mr. McKay discovered a large series of remains of the huge whale with the seal-like teeth,* called by Sir James Hector *Kekenodon onomata.*† A full description of the small deposit of calcareous greensands and of the great variety of fossils found is given on pages 67 and 68 of the Geological Report of 1881, and it will be seen from the notes that the locality is a very important one for collectors.

Crossing the Wharekuri Creek at the bridge, we put up our horse and trap at the small accommodation-house close by and walked up the creek to a small coal-mine worked in a small seam of coal, and a short distance further on the schistose beds of the older rocks forming Mount Mary come in.

On returning down the bed of the creek, about 12 chains before reaching the bridge on the main road there is a very interesting series of small faults, the main fault being nearly vertical and running N.N.W. by S.S.E. The beds here exposed on the cliffs on the east bank of the stream are about 40 ft. thick, 30 ft. of which are blue clayey sandstones very full of fossils, all squeezed and distorted; and on the down-

Fig. 1.



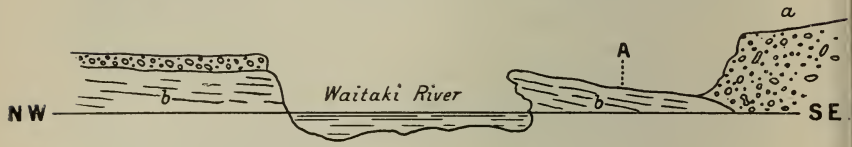
Section 12 Chains above Bridge over Main Road, Wharekuri.

a. Recent river gravels.
b. Blue clayey sandstones (fossiliferous).
c. Soft yellowish sandstone (not fossiliferous).
f. Fault, about 2 ft. wide.

* Rep. Geol. Surv. N.Z., 1881, p. 73.
† Trans. N.Z. Inst., xiii., p. 436.

throw side of the fault about 30 ft. of soft yellowish sandstone, not fossiliferous. These are capped by several feet of recent river-gravels. The fault is 2 ft. wide. (See fig. 1.)

The terrace gravels and silts form the high banks of the creek down to the junction with the Waitaki, which is here a fine river, carrying a large body of water and subject to high floods. Just at the junction of the creek the river makes a sharp turn northwards across the valley, and has swept away the overlying river-gravels from a projecting point of dark-green clayey sandstone, leaving the surface perfectly bare, and over the whole surface are small concretions of hardened sand enclosing a great variety of fossils. As far as I can make out from Mr. McKay's report,* the remarkable series of bones of



Section across Waitaki River Quarter-mile below Junction of Wharekuri Stream.

A. Where the *Aturia* was found.
a. Terrace gravels and silts, with moa-bones.
b. Dark-green clayey sandstones, very fossiliferous.

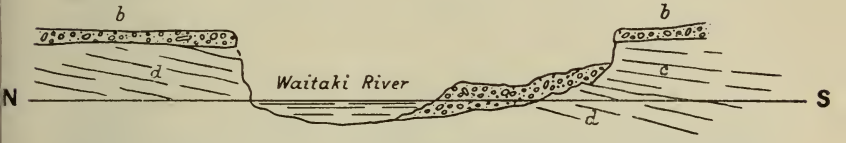
five specimens of *Kekenodon onomata* must have been obtained from the upper beds of this point before its recent erosion by the river. We were not able to find any bones or teeth of *Kekenodon*, but we were successful in collecting the fine specimen of *Aturia* figured on Plates XXXVII. and XXXVIII. The difficulty of getting this huge shell out of the hard marly greensand was very great, as a large trench had to be dug on all sides. Fortunately, sufficient of the matrix came away with it to hold the shell together until it reached the Museum, when Mr. Jennings, the skilful taxidermist, worked it out and cut it into two halves. The shell still retains the nacreous appearance. A portion of the thin outer chamber was unavoidably broken in the excavation, but the greatest diameter is still between 15 in. and 16 in.

Amongst other fossils was a very fine *Pleurotomaria* 5 in. in diameter at the base, at present undescribed, and a considerable number of a *Pecten* allied to *P. hutchinsoni*, but having one side slightly ribbed and the other smooth, like *P. Yahlensis* of the Australian Tertiaries. Mr. McKay mentioned that a large number of the concretions that he collected contained crabs. We only found one, but this is,

* Rep. Geol. Surv. N.Z., 1882, p. 68.

fortunately, well preserved, and bears a resemblance to the *Harpactocarcinus* figured by H. Woodward in the Quarterly Journal of the Geological Society (xxii., 51), but it is not that genus.

Crassatella australis was plentiful, *Trochus chathamensis*, and a number of corals. A few fragments of leaves were found, and the vertebra of a fish having a centrum 1 in. in diameter.



SECTION ACROSS WAITAKI RIVER THREE-QUARTERS OF A MILE BELOW THE JUNCTION OF THE WHAREKURI CREEK.

a. Recent river gravels.
b. Terrace gravels and silts, with moa-bones.
c. Sandy shell beds full of fossils.
d. Dark-green sandy beds.

Following down the bed of the river, the section exposed for a mile or two is a cliff of about 20 ft. of fine sandy material full of the most delicate and beautiful specimens of fossils — huge specimens of *Dentalium giganteum*, brachiopods of several species, *Natica*, *Turritella*, *Limopsis*, *Lima*, and a number of small species. A very fine collection could be made here by careful search. The conditions under which the beds were deposited seem to have been very favourable to the development of all forms of animal life in land-locked shallow seas with a mild climate.

EXPLANATION OF PLATES XXXVII. AND XXXVIII.

PLATE XXXVII.

Aturia ziczac.

PLATE XXVIII.

Section of *Aturia ziczac.*

ART. XXXVII.—*Boulders in Triassic Conglomerate, Nelson.*

By Dr. P. MARSHALL, Lecturer in Geology, Otago School of Mines.

[*Read before the Otago Institute, 9th June, 1903.*]

Plates XXXIX.–XLI.

THE following descriptions of rock-sections are given in the hope that they may help in forming an accurate idea of the age of many of the igneous rocks occurring in the older formations of the Nelson Province. In many cases the age of

igneous rocks can be most readily settled by recording their occurrence or absence as rolled fragments in fossiliferous sediments. In the present case it is evident that the parent masses from which these conglomerate fragments were derived must be older than the Triassic period. The collection was made by Professor Park from the conglomerates occurring at the base of the Triassic formation in Nelson.

C 275.—Granite. Dark-grey on weathered surface. Mica plates distinct; feldspar opaque. Stained with iron-oxide.

Section: Quartz rather plentiful, with very irregular outlines. Water clear, with undulose extinction. Feldspar partly orthoclase, twinned on the Carlsbad law; also in rather greater abundance an albite-oligoclase with extinction angle of 8°. Albite twinning general. Carlsbad less common. Zonal structure general, showing progressively lower extinction angles towards the margin. Decomposition producing cloudy appearance in centre of crystals, due to development of very minute epidote crystals and other substances too fine-grained for recognition. Hornblende in idiomorphic crystals rare, with pleochroism from dark-green to pale-yellow. Biotite more frequent, dark-green or pale-yellow, rather decomposed to a viridite substance. Sphene not abundant, granular. Very pale-grey. Slightly pleochroic.

C 276.—Granite. Fine-grained, light-pink. Biotite plates fairly large.

Quartz plentiful, perfectly clear, without undulose extinction. Feldspar chiefly microperthite, in places forming a graphitic intergrowth with quartz. Albite sometimes forming cores for microperthite. All feldspar rather decomposed and cloudy. Decomposition products very fine. Occasional small flakes of brownish-green mica. Small idiomorphic sphene, and magnetite in very small quantity.

C 277.—Granite. Pink, coarse-grained, with fairly large biotite plates. Quartz white. Feldspar pink.

Quartz abundant, perfectly clear, granular. Feldspar porphyritic, the larger crystals being orthoclase or albite. Much decomposed into epidote and muscovite. On the margins of larger grains of quartz and feldspar a granular intergrowth, the nearer portions of mineral matter similar optically to the crystals; has similar orientation with them. Otherwise the structure is microgranitic. A little brownish-green biotite, magnetite, and two or three minute crystals of zircon. No sphene visible in the section.

C 278.—Granite. White, coarse-grained. Quartz white. Biotite plates not present. Feldspar white.

Quartz clear, in large grains, on the exterior of which there is often an intergrowth of feldspar. Feldspar chiefly orthoclase, rather decomposed, much intergrown with quartz, even in the interior of large crystals. Cloudy with minute decomposition products. No ferro-magnesian minerals. A few irregular grains of sphene, showing distinct pleochroism.

C 279.—Granite. Dull-pink. Porphyritic quartz. Biotite small.

Section generally similar to C 277, but quartz rather coarser. In places microgranitic structure, but generally micrographic. Brown biotite more abundant than in C 277, and magnetite much pierced by crystals of apatite. No sphene or zircon visible.

C 280. — Granite. Large white crystals of porphyritic feldspar in pink fine-grained base.

Section similar to C 275, but coarse-grained. Feldspar includes orthoclase, albite, and microperthite twinned in the usual way. Large flakes of brown biotite with apatite needles. No hornblende. A little magnetite and sphene.

C 281.—Diorite. Dark hornblende in irregular crystals. Grey feldspar.

Feldspar crystals allotriomorphic, showing twinning on albite and occasionally on pericline laws. Extinction angle 30°, indicating an acid labradorite. Much decomposed into comparatively large crystals of epidote, muscovite, quartz, and "garnet." Hornblende plentiful in light-green crystals pleochroic from green to pale-yellow, occasionally twinned. Much intruded by various inclusions for the most part originally feldspar and apatite. Now decomposed like the surrounding feldspar. No magnetite or other accessory minerals.

C 282. — Porphyry. Feldspar phenocrysts green. Base greyish-brown.

Phenocrysts of orthoclase idiomorphic, twinned on Carlsbad law; much decomposed, apparently into sericite. Smaller phenocrysts of epidote, but crystals not optically single, but aggregates. Form similar to hornblende, from which the mineral is derived. Base rather coarsely felsitic, but no trace of original microlites, so probably originally a glass. Felsitic matter apparently composed of feldspar and a decomposed ferro-magnesian mineral. Magnetite in fairly large grains not infrequent.

C 283.—Porphyrite. Feldspar opaque, green. Base dark-brown.

Feldspar phenocrysts much decomposed, but Carlsbad twinning still faintly seen. Decomposition products mostly chlorite, epidote, and apparently muscovite, finely divided. Brown mica fairly abundant. Groundmass glassy, with black microlites decomposed into opaque ferritic matter. Flow-structure distinct. Idiomorphic crystals of magnetite fairly abundant. In some cases pierced by apatite needles.

C 284.—Uralite porphyrite. Feldspar opaque; white, small, sharp crystals. Base nearly black.

Augite phenocrysts fairly large, partially changed into green fibrous pleochroic hornblende. Colourless when unchanged. Feldspar in two generations: Sharply idiomorphic with short forms, sometimes isometric; decomposition rather advanced towards the centre of the crystals; maximum extinction angle 30°: second generation similar in all details except size to first generation. No slender microlites. Feldspar imbedded in granular green hornblende evidently derived from augite. Magnetite very abundant.

C 285.—Porphyry. Feldspar generally glassy, with bright cleavage surfaces. Base dark-brown.

Feldspar in sharp phenocrysts, sometimes much weathered, but more often quite clear. Twinned on Carlsbad law, and perhaps occasionally on Baven's, but examples not good. Occasionally albite lamellation, indicating a plagioclase near oligoclase. Base for the most part glassy, but secondary devitrification not uncommon; many decomposed microlites changed into a ferritic substance. Chloritic pseudomorphs rather frequent. The original mineral usually hornblende, sometimes biotite. Epidote with chlorite. Secondary quartz in knots not infrequent. Angular inclusions of a shaly rock with carbonaceous matter frequent.

C 286.—Porphyry. Feldspar opaque, greenish. Base dark-brown.

Feldspar mostly orthoclase, sometimes zoned, when the exterior border gives straighter extinction than the core. Decomposition into a dusty substance (sericite) general, especially in the central portions. Flakes and needles of a bright-green chlorite also frequent. Much chlorite in cleavage cracks. Some plagioclase, with well-developed albite twinning apparently oligoclase. Pseudomorphs of chlorite after hornblende rather common. Base glassy, with well-developed

damascened structure. Magnetite grains fairly large, pierced by apatite needles.

No rocks occurring *in situ* similar to these have hitherto been recorded from the Nelson District. It is hoped that when the geology of the province is studied with the aid of petrographical investigations these descriptions will be of some value in determining the age of some of the igneous rocks.

ART. XXXVIII. — *Second Supplement to the "Materials for a Bibliography of the* Dinornithidæ."

By A. HAMILTON.

[*Read before the Otago Institute, 3rd December, 1903.*]

TEN years ago I presented to this Institute the first portion of the working-list of papers on the moa, and the subsequent year a small first supplement of items which had been accidentally omitted, for several of which I was indebted to the kindness of friends. This evening I submit another supplementary list, bringing the material for the bibliography up to date.

As in the previous lists, some papers are included which treat of the smaller extinct birds, the history of which is bound up with that of their giant relatives, the moas.

Author.	Title of Paper.	Name, &c., of Publication.
Andrews, C. ..	On the Extinct Birds of the Chatham Islands. Part I.: The Osteology of *Diaphorapteryx hawkinsi*	Nov. Zool. iii. 73, pl. iii.; 1896.
	On the Extinct Birds of the Chatham Islands. Part II.: The Osteology of *Palæolimnas chathamiensis* and *Nesolimnas* (n. gen.) *dieffenbachi*	Nov. Zool. iii. 260, pl. ix. and x.; 1896.
	Note on a Skeleton of *Diaphorapteryx hawkinsi*, Forbes, a Large Extinct Rail from the Chatham Islands	Geol. Mag. (Dec. iv.) iii. pl. xii.; 1896.
	Note on a Nearly Complete Skeleton of *Aptornis defosser*, Owen	Geol. Mag. (Dec. iv.) iii. pl. x.; 1896.
Benham, W. B. ..	Notes on the Fourth Skin of *Notornis*	Trans. xxxi. 146; 1897.

Author.	Title of Paper.	Name, &c., of Publication.
Benham, W. B. ..	Notes on Certain of the Viscera of *Notornis*	Trans. xxxi. 151; 1897.
	Notice of the Discovery of a Moa-egg Shell	„ xxxi. 738; 1897.
	On the Entire Egg of a Moa, now in the Museum of the University of Otago	„ xxxiv. 149; 1901.
Colenso, W. ..	Notes and Observations on M. A. de Quatrefages' Paper "On Moas and Moa-hunters," republished in Vol. xxv., Trans. N.Z. Inst.	„ xxvii. 498; 1894.
Chapman, F. R. ..	Notice of the Discovery of a Complete Moa's Egg	„ xxxii. 438.
De Vis, C. W. ..	The Moa in Australia ..	N.Z. Journ. Sc. (new issue) i. 97; May, 1891.
Ewen, C. A. ..	On the Discovery of Moa-remains on the Riverton Beach, Southland	Trans. xxviii. 651; 1895.
Hamilton, A. ..	Further Contributions towards Bibliography of the *Dinornithidæ:* Supplement No. 1	„ xxvii. 228; 1894.
	On the Feathers of a Small Species of Moa (*Megalapteryx*) found in a Cave at the Head of the Waikaia River; with a Notice of a Moa-hunter's Camp on the Old Man Range	„ xxvii. 232; 1894.
	Notes on a Deposit of Moa-bones at Macrae's	„ xxix. 629; 1896.
	Notes on a Specimen of *Eurapteryx* from Southland	„ xxx. 445; 1897.
	On *Cnemiornis calcitrans* and *C. minor*	„ xxx. 581; 1897.
	On the Distribution of *Notornis*, and General Notes on the Genus	„ xxxi. 739, 743; 1898.
Hector, Sir James	On a Discovery of Bones of *Dinornis giganteum* on the Surface	„ xxvii. 655; 1894.
	Notes on Moa-bones in Gold-drift	„ xxix. 607; 1896.
	On the Distribution of Moa-remains in New Zealand	„ xxxiv. 562; 1901.
Henry, R. ..	On the Probable Origin of *Notornis mantelli* and its Extinction in New Zealand	„ xxxii. 53; 1899.
Hill, H. ..	On the Occurrence of Moa-footprints in the Bed of the Manawatu River near Palmerston North	„ xxvii. 476; 1894.
Hutton, Captain F. W.	On the Axial Skeleton in the *Dinornithidæ*	„ xxvii. 157; 1894.
	On the Occurrence of a Pneumatic Foramen in the Femur of a Moa	„ xxvii. 173; 1894.

Author.	Title of Paper.	Name, &c., of Publication.
Hutton, Captain F. W.	On a Deposit of Moa-bones at Kapua	Trans. xxvii. 627; 1894.
	On a Deposit of Moa-bones from Enfield	„ xxviii. 645; 1895.
	The Moas of the North Island of New Zealand	„ xxix. 541; 1896.
	On the Leg-bones of *Meionornis* from Glenmark	„ xxix. 557; 1896.
	On Two Moa-skulls in the Canterbury Museum	„ xxix. 561; 1896.
	On the Footprint of a Kiwi-like Bird from Manaroa	„ xxxi. 486; 1896.
	On a Moa-bone from Silt at the Port Hills	„ xxxi. 731; 1896.
Lydekker, R., &c.	..	Dictionary of Birds: "Moa," pt. ii. 575.
	On a Complete Skeleton of *Megalapteryx tenuipes* in the Tring Museum	Nov. Zool. iv. 188, pl. vi.
Mantell, W. B. D.	Obituary of	Geol. Mag. (Dec. iv.) iii. 239; 1896.
McLeod, H. ..	On Caves in the Martinborough District, and Moa-bones found therein	Trans. xxxiv. 562; 1901.
Meyer, A. B. ..	On the Eggs of the Moa ..	Ibis (ser. 8) iii. 188.
Milne-Edwards, A	Sur les Resemblances qui existent entre la Fauna des Iles Mascareignes et celle de certaines Iles de l'Ocean Pacifique Australe	Ann Nat. Sc. (8) i. 117, pl. xi.–xiii.; 1895.
Parker, T. J. ..	The Cranial Osteology Classification and Phylogeny of the *Dinornithidæ*	Tr. Zool. Soc. L. xiii. 373, pl. lvi.–lxii.; 1893.
	Notes on the Species from Enfield, near Oamaru	Trans. xxvi. 24; 1893.
	Remarks on the Leg-bone of *Megalapteryx*	„ xxvii. 684; 1894.
	Remarks on a Skeleton of *Harpagornis*	„ xxix. 628; 1896.
	Remarks on a Skeleton of *Harpagornis*	„ xxx. 574; 1897.
Shufeldt, R. W. ..	On the Affinities of *Harpagornis*, in a Letter to Professor T. J. Parker	„ xxviii. 654; 1895.
Tegetmeier, — ..	Tracheal Rings and Feathers of *Dinornis*	Bull. B.O.C. xi. 56.
White, Taylor ..	The Moa and the Maoris ..	Trans. xxviii. 761; 1895.
	Notes on the Poua and other Extinct Birds of the Chathams	„ xxix. 633; 1896.
	Have we Remains of a Swimming Swan-like Moa?	„ xxx. 586; xxxii. 339.
	The Bird Moa and its *Aliases*	„ xxvii. 262; 1894.

Art. XXXIX. — *Note on Remains of some of the Extinct Birds of New Zealand found near Ngapara.*

By A. Hamilton.

[*Read before the Otago Institute, 3rd December, 1903.*]

A short time ago Professor Benham, the Curator of the Otago University Museum, brought under my notice some bird-bones which had been sent to him for identification by the Rev. Jas. Standring, of Enfield, a small settlement eight miles inland from Oamaru.

The bones were in a very good state of preservation, and included bones of the *Harpagornis*, *Cnemiornis*, and several other smaller birds. One small metatarsal was shown to me as something strange, and at first I thought the bone was that of one of the hawks. Closer examination, however, enabled us to identify it as belonging to a bird closely allied to *Corvus corax*. There was also a metacarpal of the same bird.

It then became highly probable that this must be the same genus, at any rate, as *Corvus moriorum*, described, or, rather, named, by Forbes from collections made in the Chatham Island. On borrowing from Mr. Kinsey, in Christchurch, who possesses a magnificent skeleton of this very rare bird, a bone of the *Corvus moriorum* the identification was assured.

It is a matter of extreme interest to find this bird in New Zealand, and, as I have already found another of Mr. Forbes's species, a *Fulica*, in the deposit of bird-bones at Castle Rock, in Southland,* it was of special interest to me.

Professor Benham kindly arranged with Mr. Standring so that we could visit the locality in which the bones were found, but, unfortunately, he was prevented from going at the last moment, so it fell to me to make an examination of the locality, and, if possible, to ascertain how the bones came into the position in which they are found.

Mr. Standring was kind enough to meet me at the Windsor Station, and had arranged that we should be driven by Mr. McCulloch, the owner of the property on which the bones are found, to the place, which is about two miles and a half from the terminus of the line at Ngapara, or about twenty miles from Oamaru.

The road passes up a valley cut through a succession of sandy clays and gravels capped with a bed of limestone.

Mr. McCulloch's house is situated in the midst of most

* Trans. N.Z. Inst., vol. xxv., p. 88.

picturesque masses of this band of limestone which have broken away from the main body of rock and slid or rolled towards the centre of the valley. All round the valley and its branches appear the vertical limestone cliffs, averaging about 100 ft. in height, and are about 800 ft. above sea-level. The spot where the bone of the crow was found was first examined, and proved to be very limited in area and poor in bones, although I commenced by digging up a fine calvarium of *Cnemiornis* just below the surface, and therefore expected great things. We then proceeded to examine a cave some distance further from the house. Here we had to descend about 25 ft. through a narrow crack in the rock parallel with the general direction of the face of the cliff. These narrow cracks are very numerous, and if they could be examined to a considerable depth I have no doubt would yield many treasures. Proceeding a short distance along the bottom of the fissure, it presently dipped deeper, and it became necessary to light a candle. The fissure here expanded into a small cave, with remains of small stalactites on the roof and a thin layer of stalagmite on the undisturbed portion of the floor. The centre of the floor had evidently been dug over, and we were informed that some sackfuls of bones had been taken out. One or two places near the walls yielded a good many imperfect moa-bones, mainly *Pachyornis* and a few bones of *Cnemiornis*. I did not notice any small-birds' bones. The cave was dry save for some percolation from above.

On getting out of this cave we commenced an examination of the talus slope at the base of the wall of limestone, pushing our way through a dense growth of native shrubs and creepers, with here and there a large broadleaf (*Griselinia*). Wherever the ground was exposed we found traces more or less plentiful of small-bird bones, and here and there remains of large moas.

The stiff bushes of matakouri and a dense growth of horehound rendered a thorough inspection difficult. After having examined the whole of the area covered by the fallen rocks, and having walked along the edge of the cliffs on the grassy plateau above, I think that the following suggestions will be found to meet the facts of the case.

There is an almost unbroken line of cliffs for nearly three-quarters of a mile; below these, at an average distance of a chain or two, is an irregular line of rocks at all angles, which have split off and fallen away from the main mass. Below these are other rocks which have broken off at an earlier date, and which have slipped and slid further, but are still roughly parallel with the main cliff. Between the cliff and the last split-off rocks is an irregular sloping mass of soil, stones, and

vegetable *débris*, a foot or more in thickness, resting on the sandy clay underlying the limestone, and out of which the valley is excavated.

It is in this talus that the bones are found, sometimes in numbers near the top, sometimes deeply buried. An examination of the top of the cliff shows that at various distances from the edge along the whole line of cliffs are crevices

Diagram of the Mode of Occurrence of the Bird-bones at Ngapara.

A. Limestone. B. Sands and clays.

two or three feet in width—sometimes more—and these, I believe, give the key to the question. It must be recollected that before the advent of civilisation the country was covered with dense masses of bushes and trees, and that birds were numerous, so that open narrow fissures would in many cases form efficient traps for ground-birds. Let us suppose that as soon as a crack opens (owing to the denudation of the sandy clay underlying the stone) earth, leaves, and a few birds drop in, together with sticks, leaves, and vegetable *débris*, until the fissure in course of time is full, when the final slip happens, and the mass of limestone slips two or three chains down the slope; the contents of the fissure will gradually be distributed over the intervening space, a wide part of the crack contributing more than a narrow part. Vegetation

soon springs up, and assists to preserve the bones. Large broadleaf-trees more than 2 ft. in diameter are growing over the bones in some places.

A large number of the bones that I was able to dig up were broken, which is probably accounted for by the rooting of wild pigs in former days and by the rooting of domestic pigs at the present time, as the space between the rocks and the cliff is utilised as a large pig-paddock.

I dug for bones on the afternoon of one day and the morning of the next, and altogether brought back about a thousand specimens, the result of the examination of which is given below.

I am much indebted to Mr. McCulloch for his hearty assistance, and to the Rev. Mr. Standring for information concerning the locality.

Corvus moriorum (right and left metatarsi).
Notornis hochstetteri.
Fulica prisca.
Aptornis.
Apteryx (two sp.).
Anas finschii.
Cnemiornis.
Harpagornis.
Carpophaga.
Ocydromus.

And bones of a few small birds not yet worked out.

Art. XL.—*Note on a Dyke at Nugget Point.*

By R. Speight, M.A., B.Sc.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1903.*]

This dyke is mentioned by Captain Hutton in the "Geology of Otago," pages 41 and 42, and also by the Geological Survey in several reports on the district. My attention was drawn to it during a visit to Nugget Point in January, 1903. On examining hand-specimens subsequently one or two features of the rock attracted my notice. It belongs to a division of the syenite group not common in New Zealand—viz., feldspar porphyry. This is evident from the inspection of hand-specimens. The porphyritic feldspars constitute the bulk of the rock, the size of the crystals ranging up to 5 mm. in length. They show the characteristic shapes due to pinacoidal cleavages, and from the absence of twin striation they are most probably to be classed as orthoclase. This is confirmed by flame tests. No other porphyritic mineral could be observed in a macroscopic examination, but a number of inclusions of foreign material occur. These I took at first for altered feldspars, but I believe they have been caught up

in the rock as it passed through underlying beds. They are usually small, but I observed one a centimetre in length.

The specific gravity of the rock is 2·65. This is rather low for a syenite, but the small amount of basic mineral present and the large predominance of orthoclase feldspar accounts for it.

A partial chemical analysis gave the silica-percentage as 58. This is also low for a syenite. This may be explained by the small amount of free silica and the large amount of altered feldspar present in spite of the comparatively small amount of ferro-magnesian mineral that occurs.

A microscopic examination shows that the rock is principally composed of idiomorphic feldspars in a crystalline groundmass. The feldspars are much clouded by alteration, and occasionally occur as binary twins; others show undulose extinction and zonal structure. They are mainly orthoclase, but plagioclase is also present. In sections from the middle of the dyke quartz is rare, but in sections from the edge it was observed in small individual crystals, and also replacing feldspar as a mosaic of small grains. This is perhaps due to pressure as well as to the alteration of the feldspar.

The ferro-magnesian mineral which, no doubt, occurred originally in the rock has been replaced by chloritic material which shows at times a doubtful pleochroism. The small percentage of ferro-magnesian mineral is characteristic of feldspar porphyries. However, on digesting the powdered rock with hydrochloric acid for twenty-four hours the solution gave, with ammonia, a decided precipitate of ferric hydrate. This must have come partly from the alteration products and from small crystals of iron-ore forming an original constituent of the rock. The groundmass is at times hard to determine, owing to alteration, but it appears to consist of small feldspars, which are so completely clouded as to be opaque between crossed nicols. In the finer portions of the rock the groundmass is clearly holocrystalline. A larger quantity of free silica is also present here. The porphyritic crystals, too, do not exhibit a distinct crystalline outline, but have the form of allotriomorphic grains.

The inclusions in the rock, which I took at first for altered feldspars, are most probably fragments of a trachytic or andesitic lava. They consist of a semi-crystalline groundmass, and in one I noticed small porphyritic crystals of plagioclase which had undergone a certain amount of alteration, but not sufficient to render their determination at all doubtful. No ferro-magnesian minerals occur in them, but I should say they are most probably fragments of andesitic lava. It is possible that they have been produced from feldspars by metasomatic processes, but I think it hardly likely. As vol-

canic rocks of a greater age are known to occur in other parts of Southland at no great distance, it is not unlikely that they underlie the rocks of the Hokonui system at Nugget Point, and the presence of derived fragments in a dyke penetrating them would not be at all improbable.

The date of the intrusion of the dyke can be fixed with tolerable certainty. It is found in Triassic rocks, so that it cannot be earlier than that period. Further, I found near it a derived sedimentary rock which contained a small *Monotis*. If the rock was really formed from the dyke it fixes the date for the close of the Triassic period, or not later than early Jurassic. There is some difficulty, however, in determining accurately the origin of the derived sandstone, as the sandstones in the immediate neighbourhood are highly feldspathic, but contain a large proportion of plagioclase. However, I did not notice this in the derived volcanic sedimentary rock. A granite intrusion occurs in the neighbourhood at Omaru Creek (see paper by Captain Hutton, read before the Royal Society of New South Wales, 1889). This is on the same line of country, and from the description of the rock there are marked affinities to the one at Nugget Point. They may therefore be of the same age.

Art. XLI.—*Some Caves and Water-passages in the Greymouth District.*

By H. N. McLeod.

[*Read before the Wellington Philosophical Society, 1st July, 1903.*]

In the following note will be found illustrations of the action of water in forming caves and underground passages in two different ways, in the one by percolation from a ridge-top, and in the other by overflow from flood-waters.

The latter instance is to be found in the vicinity of Kumara, on the left bank of a stream known as Whisky Creek, which obtains its name from its flowing by the site of a raided still. Here, a few chains above the point where the track crosses the bed, the flood-waters pass into an underground passage, which, after expanding into a vault, branches into other passages. The outlets to these were not traced, but without doubt drain into the River Teremakau, which is not far distant. An entrance was forced through *débris* which almost closed the entrance, and a distance of a hundred paces was traversed, when further progress was barred by the silting-up of this passage. Return was made to the vault, and another passage traversed for fifty paces. The descent of this was not without some difficulty, owing to sudden drops

and to the slippery nature of the bottom and sides. At this point a muffled sound of falling water was heard, when it was considered advisable to return, owing to the light of the lamp failing. Daylight was reached after some trouble. The passages vary from 4 ft. in diameter to about 10 ft. high and 6 ft. wide, and bear signs of channelling action. Stones washed from the creek cover the floor in places, but do not occur in the sides.

Another passage not far distant from the above was also explored, and was interesting as marking the course of an earlier bed of the stream. It lies about 30 ft. from the present bed, and is on a higher level. Its length before narrowing to a manhole in size is 50 paces, its depth roughly 8 ft., and width 5 ft., the bottom overlaid with slippery mud. The journey to the spot is sufficiently interesting in itself to repay the trouble of the visit. Leaving Kumara, the Teremakau Bridge is crossed, evidences of gold-workings being abundant; then across the Greenstone by suspension bridge. Deep Creek (four miles), a small cañon said to be 70 ft. deep, is crossed. Thence a mile and a half by bush track, full of interest to the lover of scenery, brings one to the creek.

Ten minutes' walk from the hotel at Greymouth brings one to any one of three examples of the effect of water percolating, gathering into a stream, undermining the overlying strata, and forming caves or crevices. There are others at hand also, in one of which the celebrated West Coast chief Tainui, I am told, is buried; but a description of the chief one will be sufficient for illustration. This is situated on the far side of the River Grey from Greymouth, just where the old bridge terminates. The entrance is about 20 ft. wide by 7 ft. high. Much care is necessary in looking through this cave, as the footing is unsafe, and a tumble of 20 ft. into a pool at the bottom is an experience to be avoided. On the left after entering is a passage descending to water-level, from which there proceeded sounds resembling the sharp puffing of a locomotive. The main portion extends sixty paces; after it is a passage of some length, accessible, however, only to the small boy. At different places shafts or passage-ways open into the main cave. These bring water from the hilltop above, if flax-seeds found on the sides of one tell any tale. Large blocks of strata have fallen from the roof and in turn been worn away and carried off as muddy water into the Grey River.

A study of the formation of this cave is specially interesting, enabling, as it does, an opinion to be formed of the action by which the Grey River evidently broke through the chain of hills at Greymouth, forsaking the old channel, which, according to authoritative opinion, discharged its waters at a point seven miles distant.

V.—CHEMISTRY AND PHYSICS.

Art. XLII.—*On the Regeneration of Cyanide-solutions.*

By Godfrey Doveton, M.A.I.M.E.

Communicated by Professor James Park.

[*Read before the Otago Institute, 13th October, 1903.*]

Case 1.—The recovery of the cyanide from the inert compound K_2ZnCN_4, which is formed during the precipitation of the metals upon zinc-shaving, filiform zinc, &c.—zinc fume, emulsion, or dust. Thus—

$$Zn + 4\ KCN + 2\ H_2O = ZnK_2CN_4 + 2\ KOH + H_2.$$

To the solution containing the double cyanide of zinc a certain amount of a caustic alkali is added. Thus, with caustic potash—

$$ZnK_2Cy_4 + 4\ KHO = Zn(CK_2) + 4\ KCN + 2\ H_2O.$$

The requisite amount of caustic alkali is readily found by a simple laboratory experiment.

To the solution containing potassium-cyanide and zincate of potash is now added a certain quantity of alkaline sulphide, slightly less than actually required to throw down all the zinc as sulphide. Thus—

$$Zn(CK)_2 + 4\ KCN + 2\ H_2O + Na_2S = ZnS + 4\ KCN + 2\ KHO + 2\ NaOH.$$

The requisite amount of alkaline sulphide is regularly found by simple laboratory experiment.

Case 2.—Recovery of total cyanide, where so desired, either from foul solutions or weak waste solutions.

A. Determine amount of available KCN.

B. Determine amount of total KCN.

C. Determine amount of protective alkali. If much of C is present it will be found of advantage to partially neutralise, to prevent high consumption of zinc salt in the following operation.

D. To the tank of solution add sufficient zinc salt to precipitate all the cyanides as zinc-cyanide. Thus, with zinc-chloride—

$$2\ KCN + ZnCl_2 = ZnCy_2 + 2\ KCl.$$

Also—

$$K_2ZnCN + ZnCl_2 = 2\ ZnCy_2 + 2\ KCl.$$

Also, with the copper compound, if any—

$$ZnCl_2 + K_2Cu_2CN_4 = ZnCu_2CN_4 + 2\ KCl.$$

Collect the granular precipitate of $ZnCy_2$—and in case of copper $ZnCu_2CN_4$—by means of filter press, or any other means of filtration or decantation. Reject the supernatant liquor, which will be found to be entirely free from either available cyanide, total cyanide, copper, and containing perhaps a doubtful trace of the precious metals.

The Au and Ag are almost entirely precipitated on addition of the $ZnCl_2$.

And add to it a concentrated solution of caustic alkali, sufficient to dissolve the cyanide precipitate. Thus—

$$ZnCy_2 + 4\ KHO = Zn(OK)_2 + 2\ KCN + 2\ H_2O.$$

Thus, with copper compound—

$$ZnCu_2CN_4 + 4\ KHO = Zn(OK)_2 + K_2Cu_2CN_4.$$

To the highly concentrated solution of potassium-cyanide and potassic cupro-cyanide (if copper be present in the original mill solution), also containing zincate of potassium, we now add the requisite quantity of alkaline sulphide for the purpose of removing the latter compound, $Zn(OK)_2$, care being taken to use, as previously directed, a slightly less amount of Na_2S than is actually required to remove the whole of the zinc.

It is now desired to recover the cyanide now held up by the copper in the solution as $C_2Cu_2CN_4$.

Case 3.—The highly concentrated solution of KCN, almost entirely freed from zincate of potash, but containing a portion of its cyanide combined in the inert compound $K_2Cu_2CN_4$, is now subjected to the action of a very weak electric current in a precipitation-box similar to that used in the Siemens-Halske process, though from the fact that a highly concentrated solution is to be operated upon the box may be much smaller than ordinarily; in practice, 100 tons of foul or waste mill solution can be readily concentrated into 5 tons. A current of 2·5–3 volts is found most suitable, with a volume of ·0076 amperes per square foot. The negative pole of the dynamo or batteries, as the case may be, is connected with the cathodes, which are *very thin* copper plates, not necessarily pure. The positive pole of plating dynamo or batteries is connected with the anodes of the box, which are *thick* zinc plates.

The electrical action causes the potassic cupro-cyanide to split up, the copper precipitates readily upon the cathodes, along with any bullion which may be contained in the solu-

tion, and HCN is evolved, which in its turn attacks the zinc plates, or anodes, and combines therewith to produce additional double cyanide of zinc and potassium—ZnK_2CN_4.

Thus, the solution during passage through the box is deprived of its copper, the place of the double cyanide of copper and potassium being taken for an equivalent amount of the double cyanide of zinc and potassium, from which latter salt the cyanide may readily be obtained in the available form of free potassium-cyanide by the method explained previously in Case 1.

Should it be desired to ship the cyanogen product to market, it is shipped readily as the simple zinc-cyanide $ZnCy_2$, the precaution being taken to pack it, while damp, in airtight cases. When allowed to dry much of it is converted to carbonate. To make the $ZnCy_2$ available for gold-extraction purposes it is, as previously explained, dissolved in a caustic alkali, the excess of zincate of soda or potash being removed by addition of an alkaline sulphide.

N.B.—It is advantageous, to promote perfect precipitation both in the precipitation of the cyanides with zinc salt and in the precipitation of the zinc as ZnS, and in the electrical precipitation of the copper and bullion, to cause active circulation, which is best occasioned by the employment of compressed air.

In the electrical precipitation-box the distance between cathode and anode should be $\frac{1}{2}$ in. Beginning with a thick plate of zinc and a very thin sheet of copper, you end with a thin frayed sheet of zinc and a thick plate of copper containing small amounts of bullion.

Art. XLIII.—*Studies on the Chemistry of the New Zealand Flora.*

By Thomas H. Easterfield, Professor of Chemistry in the Victoria College, and B. C. Aston, Chemist to the Department of Agriculture.

[*Read before the Wellington Philosophical Society, 2nd September, 1903.*]

Part III.—Rimu-resin.

The wide distribution of resinous substances in the vegetable kingdom naturally raises three questions: (1.) What is the function of resins in the plant-economy? (2.) What is the chemical origin of the resins? (3.) Are all the plant-resins closely related from the chemical standpoint? It is in the hope of finding evidence which may help in arriving at an

answer to these questions that the present investigation has been commenced.

The rimu (*Dacridium cupressinum*) is one of the best known and most widely used of the New Zealand forest-trees; its timber is highly resinous, and the heart-shakes, which are frequently large, contain an opaque pinkish resin which may completely fill the cracks or only occur in warty globules having a concentric structure.

Rimu-resin dissolves for the most part in alcohol, but leaves a small residue of a red amorphous substance, which has a bitter and astringent taste. If water be added to the alcoholic solution until a faint turbidity results, and the solution be allowed to stand for some hours, the greater part of the resin separates in the form of almost colourless hexagonal plates, which can be completely decolourised by recrystallisation from dilute alcohol. The crystalline compound thus obtained is strongly acid, and the name "rimuic acid" is proposed for it.

Rimuic acid is very sparingly soluble in water, benzene, and light petroleum; easily soluble in alcohol, ether, and hot acetic acid. It melts at 192°–193° C., and has the specific rotation $[\alpha]_D = -150°$.

Two preparations of the acid were analysed. The analyses and molecular-weight determinations agree with the formula $C_{16}H_{20}O_3$.

Calculated for $C_{16}H_{20}O_3$.		Found. I.	II.
C = 73·8	...	73·8	73·7
H = 7·7	...	7·9	7·95
O = 18·5			
100·0			
M.W. = 260	...	266 and 288 by cryoscopic methods, 264 by titration.	

The following salts have been analysed:—

Acid Ammonium Salt—$(C_{16}H_{20}O_3)_2$, NH_3, H_2O.—This salt is sparingly soluble in water; it is readily obtained by saturating a solution of ammonia with the acid, filtering at once, and gently warming the filtrate.

Calculated.		Found.
$NH_3 + H_2O = 6·7$	...	... 6·3
$NH_3 = 3·14$	...	... 3·0

Barium Salt—$(C_{16}H_{19}O_3)_2$, Ba, 14 H_2O.—This most characteristic crystalline salt separates in well-developed square plates when a solution of barium-chloride is added to a solution of the acid in excess of ammonia. Three preparations gave—

Calculated.		Found.		
		I.	II.	III.
H_2O = 27·7	...	27·7	27·1	27·7
Ba = 15·1	...	15·8	15·3	15·1

Silver Salt—$C_{16}H_{19}O_3$, Ag.—An amorphous flocculent precipitate prepared from a solution of the barium salt.

Calculated.			Found.
Ag = 29·4	...	...	29·0 and 29·7

Benzoyl Rimuic Acid.—This compound was prepared by shaking the alkaline solution of rimuic acid with excess of benzoyl-chloride. It is sparingly soluble in cold alcohol; from hot alcoholic solutions it separates on rapid cooling as a transparent jelly, which becomes crystalline on standing.

Calculated for $C_{15}H_{18}O$, C_6H_5CO, CO_2H.				Found.
C = 75·8	...	...	...	75·6
H = 6·6	...	...	...	6·6

Rimuic acid boils at 296°–300° at 21 mm. By continued heating at 300° it loses water, and is converted into a colourless compound which is no longer soluble in alkalis, ether, or the usual organic solvents, and cannot be distilled without decomposition. Rimuic acid does not yield an ethereal salt when treated with absolute alcohol and hydrochloric-acid gas. It readily forms two crystalline nitro-acids and a sulphonic acid, which will be described in a later paper.

It is of interest to note that *Podocarpus cupressinum*, a tree occurring in Java, contains as the chief constituent of its heart-resin an acid (podocarpic acid) which is so similar to rimuic acid that the two compounds might readily be mistaken for one another. Upon comparison it becomes clear that the two acids belong to the same homologous series—$CnH_{2n-8}OH$, CO_2H.

	Rimuic Acid, $C_{16}H_{20}O_3$.		Podocarpic Acid, $C_{17}H_{22}O_3$.
M.P.	192–193° C.	...	186–188° C.
$[\alpha]_D$	−150°	...	+ 136°

The acids differ in the number of molecules of water with which their salts crystallize. The following points of resemblance are remarkable: Both yield sparingly soluble acid ammonium salts which crystallize with one molecule of water. Both yield anhydrides when heated to 300° C. Both yield crystalline mono and dinitro derivatives the acid salts of which are yellow, the normal salts scarlet or crimson. The dinitro derivatives are peculiarly sensitive to the action of light. Both acids, again, dissolve readily in cold concentrated sulphuric acid, and yield sulphonic acids the barium salts of which are sparingly soluble and highly

crystalline. Upon diluting the crude sulphuric-acid solution with water the smell of valeric acid is in each case distinctly perceptible.

The solution of either of the sulphonic acids when warmed with very dilute nitric acid gives a yellow precipitate, the formation of which may be used as a test for nitric acid.

Art. XLIV.—*Note on Interaction of Citric and Sulphuric Acids.*

By James Bee.

[*Read before the Wellington Philosophical Society, 4th November, 1903.*]

During the preparation of aconitic acid by Hentschel's method (in which citric acid is heated with a 66-per-cent. sulphuric acid under a reflux condenser) it was found that the yield varied very considerably according to the length of time during which the acids were heated together. If the reaction were carried on for too short a time unchanged citric acid was left behind; if the heating was continued for twelve hours instead of six very little aconitic acid separated from the mixture on cooling; and in a third experiment, in which the materials were heated on a reflux apparatus for twenty-four hours, no crystallization took place after cooling.

It was found that, on pouring off the black liquid from the vessel in which the reaction had taken place, a small black deposit resembling charcoal was left. This turned out to be undecomposed aconitic acid. Suspended in the dark liquid was a flocculent dark-brown precipitate, which was separated from the liquid by straining through a large Buchner filter. From this a little aconitic acid was isolated.

The filtrate was diluted with water and extracted many times with ether. The united residues were recrystallized from glacial acetic acid, whereby aconitic acid was separated. The mother liquors were freed from acetic acid by evaporation with water, the residue taken to dryness and recrystallized from chloroform and acetone. By this means a small quantity of an acid which melted at 206° C. (uncorrected) was obtained. Upon combustion it gave numbers agreeing accurately with those of diconic acid, $C_9H_{10}O_6$.

Calculated for $C_9H_{10}O_6$.		Found.
C = 50·47 per cent.	...	50·49
H = 4·67 „	...	4·56
O = 44·86 „	...	44·95

Diconic acid was prepared by Hergt by heating citric acid and strong hydrochloric acid in sealed tubes to 190°, and according to him melted at 199–200° C.

There can be little doubt of the identity of the two substances, more especially as they agree in the following qualitative reactions: (1.) A solution of the ammonium salt of the acid gave, with ferric chloride, an orange precipitate which was not dissolved on boiling. (2.) Barium-chloride gave no precipitate either cold or hot. (3.) Calcium-chloride gave no precipitate either cold or hot.

Notwithstanding that the yield of diconic acid by this method is disappointingly small, the observation that it does result by the action of sulphuric acid at comparatively low temperatures is not only worthy of note, but suggests that by suitable variations of the conditions of the reaction the substance may be prepared in large quantities by some easy method, instead of the exceedingly tedious process described by Hergt.

During the investigation certain hitherto unnoticed peculiarities in the silver and barium salts of aconitic acid were observed: (1.) Silver-aconitate, on being heated, decomposes with explosive violence. (2.) Ammonium-aconitate: On adding a solution of barium-chloride to a solution of ammonium-aconitate no precipitate is formed, but on boiling the solution a crystalline precipitate results. The precipitate does not dissolve on cooling, but becomes gelatinous. It is insoluble in a solution of ammonium-benzoate, but soluble in a solution of ammonium-acetate.

The reaction is very characteristic, taking place even in dilute solution.

Art. XLV.—*An Experiment bearing on the Wave Theory of Light.*

By J. S. S. Cooper, M.A., B.Sc.

[*Read before the Otago Institute, 9th June, 1903.*]

1. Theory.

Consider a parallel plate of some transparent medium whose refractive index varies as the distance of the point from an initial plane at right angles to the face of the plate. Let light from a distant source (a plane wave) be incident normally on this plate. The wave theory indicates that there will be a deviation.

Let the thickness of the slab be t, and let a small element of the wave-front be AB (fig. 1), measured parallel to the

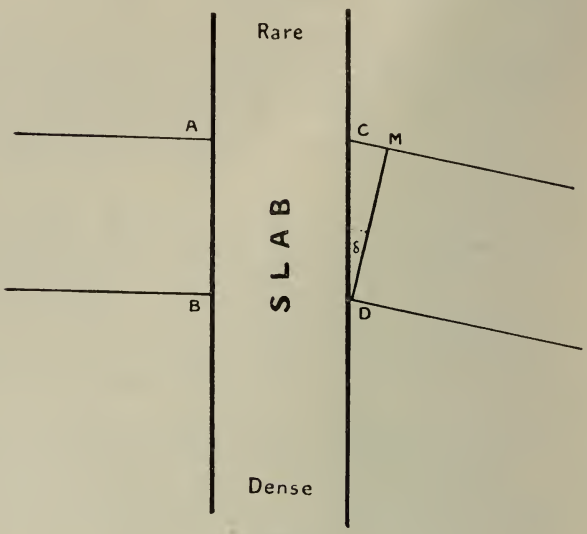


Fig. 1.

plate, but at right angles to the initial plane. Let this wave emerge from the plate at CD, and let its front be now DM, making an angle δ with the face of the plate. Let the refractive index along CD be μ, and that along AB be μ^1. The plate is supposed immersed in air of refractive index unity. We may consider the element DM to be plane.

$$\text{Let AB} = x;$$

$$\text{Then time taken to travel path BD} = k\mu t;$$

$$\text{Time taken to travel path AM} = k\mu^1 t + k\text{CM}.$$

$$\text{Whence BM} = \mu t - \mu^1 t.$$

$$\therefore \text{Sin } \delta = \frac{\text{BM}}{\text{BD}} = \frac{\mu t - \mu^1 t}{x},$$

if we neglect internal refractions.

From this it follows that, in order that the wave may remain plane, we must have $\frac{d\mu}{dx} = \text{constant } (= \lambda)$.

Then the deviation δ is given by

$$\text{Sin } \delta = \lambda t.$$

Or, if δ is small, δ varies as t ..... (1.)

2. Experiment. (Fig. 2.)

In order to test this experimentally the prisms were removed from a spectrometer, which was then fixed with its

graduated circle vertical and its collimator-tube horizontal. A small glass tank with approximately parallel sides was now placed at the centre of the circle, and the deviation it produced was noted. The tank was now half-filled with gasoline, and carbon-bisulphide was run in underneath by means of a funnel. In the region where they mix we have then a liquid slab fulfilling the conditions stated in the first

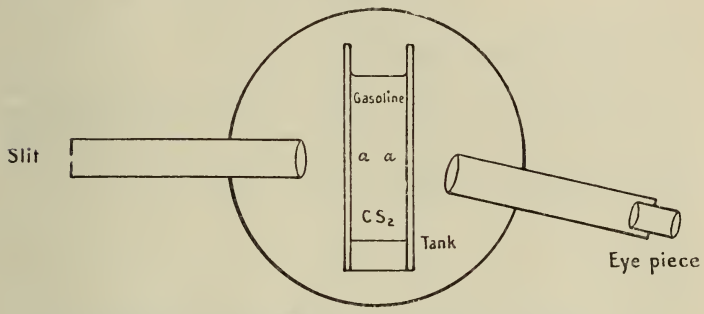


Fig. 2. Diagrammatic Plan of Spectrometer.
a a Region of mixture.

sentence of this paper. These liquids mix freely in all proportions without turbidity. The beam now passed through the mixture-layer, and the deviation was noted. At the same time a notable dispersion was observed. It then occurred to the author that these effects might be produced by prisms formed by capillary attraction in contact with the glass sides of the tank. If this were so, the introduction of a glass slip (a microscope-slide) would make four such prisms instead of two, thus doubling the deflection. A microscope-slide was carefully introduced in a vertical position, and the observed deflection was sensibly diminished. The introduction of another slab caused a further reduction of the deviation which was in sensible proportion to the thickness of the liquid traversed.

On now mixing the liquids thoroughly there was only such deviation as was accountable by the inclination of the sides of the tank, and that in a contrary direction to the previous deviations. There was no prismatic dispersion observable.

Details of One of the Experiments.

Deviation produced by glass sides of empty tank	...	$= -10'$
" by tank with gasoline	...	$= -1'$
" by region of mixture ($t =$ 7·5 mm.)... ...	...	$= +62'$
" with microscope-slip 2 mm. in thickness ($t = 5{\cdot}5$ mm.)	...	$= +44'$

Deviation produced with microscope-slip 1·6 mm. in thickness ($t = 5·9$ mm.) ... $= +47'$
" with microscope-slip 1 mm. in thickness ($t = 6·5$ mm.) ... $= +49'$
" with two microscope-slips, 2 mm. and 1·6 mm. in thickness ($t = 3·9$ mm.) ... ... $= +36'$
" by thoroughly mixed liquids in the tank) ... ... $= -3'$
Thickness of liquid layer in tank = 7·5 mm.

On the emission theory such deviation is unaccountable, if our incidence be normal. Hence we may regard this as an *experimentum crucis* for the wave theory. I have been unable to find any previous account of it. The experiments were made at Canterbury College in August, 1900.

Art. XLVI.—*The Physical Properties of Kauri-gum.*

By J. S. S. Cooper, M.A., B.Sc.

[*Read before the Otago Institute, 13th October, 1903.*]

[Preliminary Communication.]

The fossil gum from the kauri has many well-known properties peculiar to itself. It was thought worth while to make it the subject of a systematic physical investigation. Although this work is far from finished, it seems best to publish what few results have been obtained, and to supplement them at a later date. The samples used were of good quality, clear-yellow or milky in appearance, and in some cases of considerable size—up to a pound or so in weight. They were obtained from Messrs. Heather, Roberton, and Co., of Auckland.

1. General Properties.

The specific gravity varies with the milkiness—*i.e.*, with the vesicularity — so that the specific gravity of the pure substance would appear to be very constant.

Specific gravity of clear sample ... 1·076
" " milky sample ... 1·049
" " very milky sample 1·037

On being heated in the open the gum rapidly decomposes, and may be destructively distilled into a very large number of fractions. On heating under pressure in a confined space the gum may be melted as a whole, and then resolidifies nearly unchanged, but slightly more dense. During the heating to

quite moderate temperatures the pressure rises rapidly. Measured by an open mercury manometer this was on one occasion found to be over three atmospheres. If the vessel is now opened the whole mass froths up violently. A sample of the gum melted in a sealed tube showed marked surface dichroism, as do many of the fractions obtained by Mr. Prideaux by fractional distillation. It is intended to follow this part of the subject up more thoroughly.

The gum is insoluble in water, ether, carbon-bisulphide, or mineral oil. It is converted by chloroform into a jelly-like, sticky substance, but not wholly dissolved. On evaporation it resolidifies in a slightly modified form.

2. Optical Properties.

The refractive index was measured by grinding several prisms and using the method of minimum deviation. The results found give 1·54 as a mean value. No trace of double refraction could be found, even when the gum was compressed between crossed nicols up to the breaking-point. It will be interesting to examine the fluorescent dichroic oils for anomalous dispersion.

3. Thermal Properties.

A rough determination of the specific heat by the method of mixtures gave as a mean result about 0·46.

4. Electric Properties.

The gum is easily electrified by friction, and retains its charge well. This argues a high insulating-power. An attempt was therefore made to determine the conductivity by cutting a parallel slab and providing it with tinfoil discs on either side. With a water battery of 70 cells, and a Despretz and D'Arsonval galvanometer, no deflection could be observed. A deflection of a quarter of a scale division could easily have been detected. This would correspond to a specific resistance of about 10^{11} ohms per centimetre cube. The specific resistance is thus higher than that of either ebonite or paraffin. No attempt has yet been made to see how this changes at higher temperatures.

Surface conduction appears also to be very slight. The resistance between two plates 7 cm. by 5 cm. separated by a layer of powdered gum 1 mm. thick was over 9×10^9 ohms. This is due most probably to the fact that the gum is scarcely, if at all, hygroscopic.

It was found impossible at the time to obtain a satisfactory measure of the specific inductive capacity. The method used was one due to Borgman and Petrowski,* in

* "Comptes Rendus," vol. cxxviii., p. 420.

which a spectrum-analysis vacuum-tube is used. A condenser made of a slab of the kauri-gum 1·38 cm. thick was compared with one made of a slab of vulcanite 0·73 cm. thick. With the utmost care it was found impossible to obtain concordant results. The value of the specific inductive capacity appears to lie between 3·9 and 4·3, if the S.I.C. of the vulcanite in question be taken as 3·15.

The experiments were begun in 1899, but were mainly carried out at Canterbury College in 1900.

Art. XLVII.—*Note on a supposed Heat-effect.*

By J. S. S. Cooper, M.A., B.Sc.

[*Read before the Otago Institute, 13th October, 1903.*]

It is a common belief among blacksmiths that if a bar of iron with one end red-hot have this hot end plunged into water the cool end grows suddenly hotter. The effect is common to all metals, and is very striking if the cooler end be held in the hand until just uncomfortably hot.

To test if there were any real increase of temperature, or if it were merely an illusion, a brass bar was taken, ·6 cm. in diameter, and one end was turned at a right angle so as to dip easily in water. 19 cm. from this end a hole was drilled in the bar, and a copper-german-silver thermo-electric couple was soldered in. The end of the bar was heated over the flame of an oil-lamp with a chimney. This proved a steady source of heat when carefully shielded from draughts. The heating was continued for half an hour, when the deflection of the galvanometer was steady. The hot end was then plunged in cold water (about 7° C.). In about thirty seconds the deflection began to fall, and continued to do so steadily. This proves that no real rise in temperature takes place such as could affect the senses.

The effect observed must therefore be due to the continued advance of the ordinary heat-wave along the bar after cooling the end, and partly to the unconscious disappointment of the mind on failing to experience a sudden cooling.

My thanks are due to Professor Shand, of the Otago University, for his courtesy in allowing me to use his laboratory on all occasions.

Art. XLVIII.—*On certain Statistics respecting the Trend of English Trade.*

By H. W. Segar, M.A., Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 6th July, 1903.*]

There have been many statistics put forward of late as showing the smallness of the increase in British exports during some years past as compared with the increases of the exports of some other nations. That the absolute increase of the exports of the United Kingdom has been smaller than the increases of the exports of the United States of America and of those of Germany is undeniable, as is also the fact that the percentage of increase has been smaller than the corresponding percentages in the case of many other nations. But, still, many of the figures put forward, and given the most prominent place and attention as being apparently the most glaring and sensational, are very misleading, and give an extremely exaggerated view of the situation. In the course of this paper we shall examine a few typical illustrations—those, indeed, which on the surface give the most despondent view of English commerce of any I have come across. We shall see that the usual interpretation of them is wholly unwarranted, and that the attempt to make them a foundation of an attack on the free-trade policy of England can only be sustained by ignoring facts and circumstances that must be taken into account if any reasonable use is to be made of the figures. This is our main object. It is not proposed here to enter into anything approaching a complete discussion of British trade statistics, or to consider the general arguments for or against the continuation of the present fiscal policy of the United Kingdom.

Now, at least three main principles must be kept in mind if even only approximately fair conclusions are to be drawn from many of the tables of figures one comes across bearing on this question.

Firstly, we must take account of the fact that until recently general prices have been falling ever since about the year 1870. The question has been discussed by the author in

"Remarks on New Zealand's Trade and Public Debt"* and "The Flood of Gold,"† and for some information on the subject I may refer the reader to this source. Taking the average over the years 1880–89 and over 1890–99, we find a fall in prices in the ratio of 77 to 66 as measured by Sauerbeck's index numbers—*i.e.*, a fall in the ratio of 7 to 6, or some 14 or 15 per cent. Accordingly, if the exports of a country had remained exactly the same in quantity and general exchange-value from the one period to the other, the nominal value, or value in the pounds sterling of the time, would appear to indicate a fall of one-seventh, or about 14 per cent.; and the greater the exports in the former period the greater would be the apparent fall.

In Table I. are given the total nominal values of the special exports of the four leading nations commercially—namely, the United Kingdom, the United States of America, Germany, and France—for the decennial periods 1880–89 and 1890–99. The absolute increases are given in each case. These are the figures usually given; but in the table are added the approximate monetary values that the exports of the latter period would have had if money had remained of the same average value it had during the former period, Sauerbeck's index numbers having been used in the calculation. These figures represent, in terms of the money of the earlier period, and within the necessary limits of error of the estimates, the true or exchange values of the exports of the later period as compared with those of the earlier one. The corresponding absolute increases are also added.

TABLE I.

SPECIAL Values.

Country.	Exports.			Absolute Increases.	
	1880–89.	1890–99.			
		Nominal Values.	Values in Money of 1880–89.		
	Millions of £.	Millions of £.	Millions of £.	Millions of £.	Millions of £.
United Kingdom ..	2,304	2,368	2,763	64	459
United States ..	1,558	1,987	2,318	429	760
Germany	1,545	1,698	1,981	153	436
France	1,353	1,405	1,639	52	286

* Trans. N.Z. Inst., 1902, vol. xxxv., pp. 117–122.
† Trans. N.Z. Inst., 1902, vol. xxxv., pp. 122–139.

Much has been made of the facts that the apparent increase of the value of the exports for the United States is nearly seven times, and those of Germany about two and a half times, as great as for the United Kingdom. But this is true only of the nominal values, which, as we have seen, do not give a fair representation of the real changes. Considering the exchange-values, we see that the increases are much more nearly equal. The increase for the United States is just about two-thirds greater than, that for Germany is actually a little less than, and that for France is not two-thirds of the increase for the United Kingdom. There is therefore nothing alarming to be derived from these figures as thus corrected. The method, of course, as any method must necessarily be dealing with this particular subject, is comparatively rough, but the results obtained give a far better representation of the true state of things than the nominal values nakedly presented.

The above change is brought about by the making of the correction for the apparent falling-off in exports which is due merely to the change in the value of money, and, the United Kingdom having the largest exports, the correction is the greatest in the case of that country.

Secondly, we should take account of the fact that the populations of the several countries increase at various rates, and this must affect their commerce; and, further, any prosperity the commerce of a country may indicate can only be properly judged by considering it relatively to the population. The population of Germany, owing to a higher difference of birth-rate and death-rate combined with a smaller percentage of emigration, increases more rapidly than that of England, both absolutely and relatively; and the population of the United States of America, owing to the great amount of immigration, increases in both respects even more quickly. Now, comparing the exchange-values of the exports and their increases in the two periods in Table I., we see that relatively to the increases in population in the several countries England shows up better than both Germany and the United States; but it is France that really surprises us with her large increase and almost stationary population.

On account of changes in population it is much better, in comparing the commerce of nations as affecting the prosperity of their peoples, to take the trade per head; the element of population is thus eliminated. Table II. gives the special exports per head of the countries we have been considering for the quinquennial periods from 1875 to 1889. This can only be fairly used in comparing one country with another in the same period, and not in comparing period with period, because of the differences in the value of money.

TABLE II.

NOMINAL Values of Special Exports per Head.

Period.	Nominal Value of Special Exports per Head.			
	United Kingdom.	France.	Germany.	United States.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1875–79 ..	6 0 0	3 14 11	3 3 0	2 16 3
1880–84 ..	6 13 2	3 13 5	3 8 8	3 5 11
1885–89 ..	6 3 8	3 9 3	3 5 6	2 11 10
1890–94 ..	6 2 11	3 11 4	3 2 9	2 19 0
1895–99 ..	5 19 5	3 14 8	3 7 2	2 18 4

These are the figures usually given; but, to allow of approximately fair comparisons of period with period to be made, Table III. gives Sauerbeck's index numbers for the several periods, and likewise the values hence derived for the exports per head in the several periods expressed in terms of money of the same value as that of the first period, 1875–79.

TABLE III.

SPECIAL Exports per Head in Terms of the Money of 1875–79.

Period.	Sauerbeck's Index Numbers.	Special Exports per Head in Terms of Money of 1875–79.			
		United Kingdom.	France.	Germany.	United States.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.
1875–79 ..	91	6 0 0	3 14 11	3 3 0	2 16 3
1880–84 ..	83	7 6 0	4 0 6	3 15 3	3 12 3
1885–89 ..	70	8 0 9	4 10 0	4 5 2	3 7 5
1890–94 ..	69	8 2 1	4 14 1	4 2 9	3 17 10
1895–99 ..	63	8 12 6	5 7 10	4 17 0	4 4 3

It will be noticed from Table II. that the nominal values of the exports indicate a rather chequered course of trade for each country; but Table III. shows that this is due to the changing value of money, for the general exchange-values indicate continued progress in every case, except that in the case of the United States there was a falling-off in the period of 1885–89. Thus, the exports per head for the United Kingdom, instead of being a little less in the last period than in the first, as the nominal values would indicate, were really much greater, and the increase is greater than for any of the other countries.

Table IV. is deduced from Table II. It represents the percentages that the exports of each of the other three countries bear for each period to the exports per head of the United Kingdom for the same several periods. The averages of these are also added. The variations due to the changes in the value of money as well as those of population are thus got rid of, and we have a fair way of comparing the industrial prosperity of the several peoples as far as such prosperity can be measured by the mere exports.

TABLE IV.

THE EXPORTS per Head of Population of France, Germany, and the United States expressed as Percentages of those of the United Kingdom.

Period.	Percentages.			
	France.	Germany.	United States.	Average.
1875–79	62	53	47	54
1880–84	55	52	49	52
1885–89	56	53	42	50
1890–94	58	51	48	52
1895–99	64	56	49	56

Examining these results, and comparing the quinquennial period 1895–99 with that of 1875–79—twenty-five years previously—we find that in the case of France the exports per head were 62 per cent. in the earlier period and 64 per cent. in the later period of those of England; in the case of Germany the percentages were 53 and 56 respectively; and in the case of the United States they were 47 and 49. The average percentage of these three countries changed from 54 to 56 in the same time. The close approach of the numbers for each nation in two periods separated by twenty years is worthy of remark, and shows that the exports of England, when reckoned per head of population, bore practically the same relation to those of the other countries in the recent period 1895–99 as they did twenty years previously.

Between the two extreme periods there were many fluctuations. In respect to the exports per head, and relatively to the other nations, France was at her worst in the second period, 1880–84; and in the two following periods the United States and Germany were at their worst in succession. In the first and last of the five periods considered the exports per head of England were depressed relatively to their average position with respect to those of the other nations. Thus each country has had its turn in the matter of relative depres-

sion—first the United Kingdom, then France, the United States, and Germany in succession, and then the United Kingdom again. We cannot expect the course of trade to run smoothly; it is of necessity liable to fluctuations. Hence follows the advisability of considering the course of trade grouped in periods of years, so as to minimise the effect of the more temporary fluctuations. But even then we shall have fluctuations, and it no more follows from the above statistics that the condition of English exports in the last period is the beginning of a permanent change than it did in the case of the first or in any of the other periods in the case of the nation whose exports per head were relatively depressed in that period. It is impossible to draw from these figures any conclusion that would condemn the free-trade policy of England. The mere inconsistency of any such inference would be conspicuous, for, if the greater advance of the exports per head of the other countries relatively to those of the United Kingdom during 1890 is to be put down to British free trade, to what must we give credit for the very different condition of things existing from 1875 to 1889, when free trade had already been in existence for over a generation?

It would be well to point out, perhaps, that the relative recent advances of the foreign countries we have been considering in respect to the exports per head are in no wise inconsistent with the statement above that, comparing the exchange-values of the exports and their increases in the two periods in Table I. relatively to the increases in population in the several countries, England shows up better than both Germany and the United States. For, though these increases are smaller in the case of Germany and the United States relatively to the increases of population, they represent a higher value per head of the additional population than do the whole exports of the whole population, and so increase this latter value.

Thirdly, we should take into account the changes in the economic circumstances of a nation. How different the commerce can be relatively to population and resources, and consistently with the existence of the highest prosperity, is illustrated by contrasting the foreign trade of the United States, which is about £5 per head, with that of New Zealand, which is well over £30 per head. This is partly accounted for by the higher protective policy of the United States, but chiefly by other economic considerations. Changes in the economic conditions of a nation may, then, possibly tend to increase or diminish her commerce without affecting her prosperity. All these conditions must be taken into account before any change in the volume of commerce can be attributed to any particular influence. The subject is a large one,

and we have time only to barely touch upon it, remembering that our object is not to interpret the statistics fully, but rather the negative one of proving that they cannot be claimed as supplying an argument against the free-trade policy of England.

It is obvious, first of all, that there must be a limit to the development of the industries of any nation. We have seen that the commerce of England has really not ceased to advance, even relatively to her population. But England has reached a stage much nearer to this limit than her rivals. Her freedom of trade, while raising this limit, has also enabled her to approach it more rapidly. As time passes we cannot in the nature of things expect her to continue always to show either the same absolute or the same proportionate increases in her trade and industry as some of her rivals may show. Sandow is outdone every day in mere accession of strength, both absolute and relative, by growing schoolboys, who can nevertheless never hope to become Sandows. Whilst the resources of the United Kingdom generally are nearly fully developed, and some of them suffering from the first signs of exhaustion, theirs are only now being developed. They have been kept back by wars, divisions, and uncertain politics.

Again, the areas and resources of some of England's rivals in trade being so much larger than those of England, their industries and commerce must ultimately surpass hers in mere volume.

That the United States will very soon have a foreign trade absolutely greater than that of the United Kingdom is beyond doubt, because of its greater area and resources and its rapidly growing population, combined with the high industrial character of its people. I believe that Germany will not be very long in obtaining a trade equal to that of the United Kingdom in absolute value, for she has a much greater area with large resources, she has a more rapidly increasing population than the United Kingdom, and, like the United Kingdom herself, she has reached the stage of not being able to grow her own food and retain anything like the present standard of living, so that economic forces compel her to devote the labour of her additional population mainly to manufacture, and to obtain food for her people by the export of the products. These economic forces at work we cannot subdue.

We cannot, then, expect that under any commercial policy whatever England should almost monopolize for ever the manufacturing industry and the commerce of the world. Freedom of trade has enabled her, and still enables her, to utilise her resources to the best advantage, and the com-

mercial history of the world for the last century is a tribute to her energy and wisdom. But no commercial policy adds anything to her resources, puts another pound of coal in her mines, or adds another acre to her domain. Little country though she is, her history has been glorious, and her prosperity may remain exceptional relatively to her resources; but she must, in spite of any wisdom of policy, give way in the mere magnitude of her activities to countries with far greater resources. Sandow in strength must acknowledge the superiority of the elephant; train he ever so wisely, though he may excel other men he must remain a mere man. We cannot transcend the limitations of nature.

If other countries gain markets in their colonies and possessions in which their exports have special preference they are still further favoured. England has not attempted to exact such preference in her colonies. This has directly been an economic loss to her, but a great gain to them. But, on the other hand, if she had attempted to enforce such a policy the Empire no doubt would long ago have been dismembered, and she would have lost the preference, and with it the allegiance of the colonies. The complaints that have frequently been made that after all the spending of all the blood and treasure in South Africa the country has been open to the trade of all parts on equal terms sound very strange coming from an English colony. What right has England to enforce either preference with or the free admission of her goods into South Africa that she does not equally possess to enforce them on New Zealand? Those that raise their voices in condemnation of the policy of England in South Africa in this respect would be the first to resent and resist the application of any such policy to New Zealand. Still it is undoubted that preference to the Mother-country obtained from a colony or possession is a direct benefit to the Mother-country. In so far as England's rivals have achieved such a position of preference by the extension of their possessions they have gained an advantage in respect to their commerce.

Their advantage has been still further increased in so far as they have excelled the United Kingdom in the matter of technical education, in the improvement of and ready adoption of the best of machinery, and in the more economical application of their labour.

These considerations at least should all be taken into account in attempting to interpret how far the statistics of English trade prove or disprove the wisdom of England's free-trade policy, and I hope I have proved that it is absolutely unjust to draw from the figures we have examined any inference prejudicial to her commercial policy. And if in the future other nations do exhibit a much greater progress,

we shall understand, I hope, that the fact will not necessarily constitute an impeachment of free-trade principles. England is necessarily becoming relatively smaller in respect to her resources as compared with the developed resources of the whole world, and the position her industries and commerce occupy must change correspondingly. This cannot be prevented. All that can be done is to maintain and provide education and an enlightened commercial policy, and, with a spirit of enterprise, to take advantage of every opening, every improvement, and every means of economy, and so increase the return to labour and capital expended. This will insure the best possible result under circumstances otherwise beyond control. How the result is then distributed over home trade or foreign trade is a mere matter of detail. Of one thing we may be sure—namely, that, whatever tendencies may have existed of late in England to lag behind in such matters, such tendencies must have been aggravated if there had been in existence any scheme of protection. That in spite of such tendencies the United Kingdom, which is in area only a shade bigger than New Zealand, only one-half the size of France or Germany, and about one-thirtieth of the United States, should support the population she does, in the standard of comfort it enjoys, and occupy in the world to-day still the first place in respect to industry, commerce, and power are facts which constitute the most eloquent justification of her commercial policy it is possible to bring forward. The best advice that can be given to other nations that would emulate her success is "Go, thou, and do likewise."

Art. XLIX.—*A Note on Drawing for Competitions.*

By H. W. Segar, M.A., Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 6th July, 1903.*]

The question was recently put to me, in connection with a local association of clubs, whether it were possible for seven competing clubs to arrange their fixtures, in which each was to play every other, so that each club should play its matches at home and away alternatively throughout, thus removing the objectionable feature of a succession of matches played either all at home or all away.

The problem was a somewhat interesting one in arrangements, and the result came out in a form that was obviously

extensible to the case of any odd number of clubs. The arrangement cannot be completely carried out for the case of an even number of clubs, but a very close approximation to it can be made.

I have never heard of any rule or system being used in the arranging of inter-club fixtures. On the other hand, the common circumstances of the home and away fixtures being somewhat irregularly distributed, and of a few straggling fixtures generally remaining at the end of a season, for which apparently no places could be found on the dates when the main body of fixtures were played off, indicate the want of a rule which would enable a better arrangement to be carried out. It has appeared to me, therefore, advisable to give publicity to the result referred to above. It is as follows:—

Let the number of clubs be odd, and represent them by consecutive integers beginning from unity. Write down these integers in succession in a column, beginning with unity, until we have written down the middle integer; then write the next integer on the right of it and begin to ascend, writing down the remaining integers on the right of those previously written down. The last integer will be written down in the second row, the first integer remaining alone in the first row. Then begin a parallel column with the integer 2, and proceed in a similar way, writing down the integers in succession down the column until the last row is reached, and then write the next integer on the right and begin to ascend. The last integer will be written in the third row, but in the vacant place in the second row write unity. Then begin another parallel column with the integer 3, then another with 4, and so on until columns have been written down beginning with each of the integers used to represent the clubs. When the last integer has been used, continue in each case with the consecutive integers, beginning with unity, but never write a second integer in the first row.

The columns now represent the consecutive rounds, the numbers written together representing the competing clubs. Any club will play every other once. The clubs indicated in the first row have byes in the respective rounds. By subscribing "h" and "a," indicating "at home" and "away" respectively, alternately to the numbers in each column in the order in which they were written down, but beginning with the second in each case, we have the home club indicated for each match, so that no club shall play two matches in succession either at home or away.

Table I., following, indicates the result in the case of seven clubs, and Table II. the general result for $(2n + 1)$ clubs.

TABLE I.

SCHEME of Matches between Seven Competitors.

First Round.	Second Round.	Third Round.	Fourth Round.	Fifth Round.	Sixth Round.	Seventh Round.
1	2	3	4	5	6	7
2_h 7_a	3_h 1_a	4_h 2_a	5_h 3_a	6_h 4_a	7_h 5_a	1_h 6_a
3_a 6_h	4_a 7_h	5_a 1_h	6_a 2_h	7_a 3_h	1_a 4_h	2_a 5_h
4_h 5_a	5_h 6_a	6_h 7_a	7_h 1_a	1_h 2_a	2_h 3_a	3_h 4_a

Thus, *e.g.*, in the first round 1 has a bye, 2 (at home) plays 7 (away), 3 (away) plays 6 (at home), and 4 (at home) plays 5 (away).

TABLE II.

SCHEME of Matches between $(2n + 1)$ Competitors.

First Round.	Second Round.	Third Round.	——	$(2n + 1)$th Round.
1	2	3	..	$2n + 1$
2_h $(2n + 1)_a$	3_h 1_a	4_h 2_a	..	1_h $2n_a$
3_a $2n_h$	4_a $(2n + 1)_h$	5_a 1_h	..	2_a $(2n-1)_h$
4_h $(2n - 1)_a$	5_h $2n_a$	6_h $(2n + 1)_a$	..	3_h $(2n-2)_a$
5_a $(2n - 2)_h$	6_a $(2n - 1)_h$	7_a $2n_h$	..	4_a $(2n-3)_h$
⋮	⋮	⋮	⋮	⋮
$(n + 1)(n + 2)$	$(n + 2)(n + 3)$	$(n + 3)(n + 4)$	..	n $(n + 1)$

If this rule were adopted the only drawing necessary would be for the numbers to represent the several clubs, everything else would then follow.

It has already been mentioned that it is impossible to completely achieve this arrangement in the case of the number of clubs being even. The nearest approach that is possible appears to be as follows :—

Write down columns as in the case above of an odd number of clubs, taking the odd number which is one less than the actual number of clubs. Then take the even number representing the number of clubs and write it at the side of each of the solitary numbers in the first row, but alternately on the right and on the left of them consecutively. The several columns then represent, as before, the competing clubs for the successive rounds, each club playing every other once. There are, of course, no byes.

If, further, we subscribe "h" and "a," with the same meanings as before, to the numbers in each column alternately, descending with the numbers on the left and rising with those on the right, we get the home club indicated for

each match in such a way that each club plays either two matches at home or two away in succession, but this occurs not more than once for any club in the whole competition.

Table III., indicating the result for eight clubs, and Table IV., indicating the general result, the number of clubs being $2n$, will help to make this clear.

TABLE III.

SCHEME of Matches between Eight Competitors.

First Round.	Second Round.	Third Round.	Fourth Round.	Fifth Round.	Sixth Round.	Seventh Round.
$1_h\ 8_a$	$8_h\ 2_a$	$3_h\ 8_a$	$8_h\ 4_a$	$5_h\ 8_a$	$8_h\ 6_a$	$7_h\ 8_a$
$2_a\ 7_h$	$3_a\ 1_h$	$4_a\ 2_h$	$5_a\ 3_h$	$6_a\ 4_h$	$7_a\ 5_h$	$1_a\ 6_h$
$3_h\ 6_a$	$4_h\ 7_a$	$5_h\ 1_a$	$6_h\ 2_a$	$7_h\ 3_a$	$1_h\ 4_a$	$2_h\ 5_a$
$4_a\ 5_h$	$5_a\ 6_h$	$6_a\ 7_h$	$7_a\ 1_h$	$1_a\ 2_h$	$2_a\ 3_h$	$3_a\ 4_h$

TABLE IV.

SCHEME of Matches between $2n$ Competitors.

First Round.	Second Round.	Third Round.	Fourth Round.	....	$(2n-1)$th Round.
$1_h\ 2n_a$	$2n_h\ 2_a$	$3_h\ 2n_a$	$2n_h\ 4_a$	..	$(2n-1)_h\ 2n_a$
$2_a\ (2n-1)_h$	$3_a\ 1_h$	$4_a\ 2_h$	$5_a\ 3_h$	..	$1_a\ (2n-2)_h$
$3_h\ (2n-2)_a$	$4_h\ (2n-1)_a$	$5_h\ 1_a$	$6_h\ 2_a$	..	$2_h\ (2n-3)_a$
$4_a\ (2n-3)_h$	$5_a\ (2n-2)_h$	$6_a\ (2n-1)_h$	$7_a\ 1_h$	..	$3_a\ (2n-4)_h$
⋮	⋮	⋮	⋮	⋮	⋮
$n\ (n+1)$	$(n+1)(n+2)$	$(n+2)(n+3)$	$(n+3)(n+4)$	..	$(n-1)\ n$

ART. L.—*A Comparison of the Age-distribution of the Populations of the Four Chief Provincial Districts of New Zealand.*

By H. W. SEGAR, M.A., Professor of Mathematics, Auckland University College.

[*Read before the Auckland Institute, 6th July, 1903.*]

Plates XLII.–XLIV.

THE census returns of New Zealand give the distribution of the populations of the several provincial districts into the usual quinquennial age-periods. But the numbers only in each age-period are given. For the purpose of comparing the age-distributions of the populations of the provincial districts these numbers are directly of little service. It is first neces-

sary to convert them into percentages. This I have done, and the result is exhibited in Table I., which gives, for each of the four chief provincial districts and for each age-period, the percentage of the whole population of the district included in the several age-periods. The like results for the whole colony are also added.

TABLE I.

PERCENTAGES of Population of New Zealand and Four Chief Provinces in Quinquennial Age-periods.

Ages.	Percentages.				
	Auckland.	Wellington.	New Zealand.	Canterbury.	Otago.
0–5	11·64	11·67	11·28	10·54	10·44
5–10	11·03	11·26	11·15	10·88	10·88
10–15	10·90	10·64	11·09	11·39	10·98
15–20	10·58	10·56	11·01	11·76	11·31
20–25	10·35	11·34	10·81	10·87	10·84
25–30	9·02	9·39	8·89	8·58	8·78
30–35	7·53	7·86	7·38	7·08	7·30
35–40	6·02	6·51	5·88	5·67	5·51
40–45	5·21	5·31	5 00	4·95	4·78
45–50	4·29	4·38	4·24	4·34	4·29
50–55	3·49	3·44	3·50	3·71	3·62
55–60	3·06	2·59	3·04	3·24	3·33
60–65	2 59	2·06	2·68	2·91	3·11
65–70	2·09	1·42	2 09	2·08	2·46
70–75	1·14	0·76	1·11	1·15	1·30
75–80	0·57	0·39	0·51	0·51	0·56
80 and over	0·39	0·25	0·34	0·33	0·37

This table is illustrated graphically in Plate XLII.

While the age-distribution in the provincial districts resemble one another and that for the colony far more nearly than they resemble that of most other countries, still they have differences which are of interest.

In some ways these differences are more clearly exhibited by considering the excess or defect, as compared with the whole colony, of the percentages in the several age-periods for the several provincial districts. These excesses and defects are exhibited in Table II. in the form of percentages. The table gives, for each district and each age-period, the percentage of excess or defect of the number of people, actually included in the age-period, over or below what the number would be if the same total population of the district had the same age-distribution as the colony as a whole.

TABLE II.

PERCENTAGES of Proportional Excess, relative to the Whole Colony, of the Population of the Four Chief Provinces of New Zealand in the Quinquennial Age-periods.

Ages.	Percentages.			
	Auckland.	Wellington.	Canterbury.	Otago.
0–5	+ 3·2	+ 3·5	− 6·6	− 7·4
5–10	− 1·1	+ 1·0	− 2·4	− 2·4
10–15	− 1·7	− 4·1	+ 2·7	− 1·0
15–20	− 3·9	− 4·1	+ 6·8	+ 2·7
20–25	− 4·3	+ 4·9	+ 0·6	+ 0·3
25–30	+ 1·5	+ 5 6	− 3·5	− 1·2
30–35	+ 2·0	+ 6·5	− 4·1	− 1·1
35–40	+ 2·4	+ 10 7	− 3·6	− 6·3
40–45	+ 4·2	+ 6·2	− 1·0	− 4·4
45–50	+ 1·2	+ 3·3	+ 2·4	+ 1·2
50–55	0·0	− 1·7	+ 6·0	+ 3·4
55–60	+ 0·1	− 14·8	+ 6·6	+ 9·5
60–65	− 3·4	− 23·1	+ 8·6	+ 16·0
65–70	0·0	− 32·1	0·0	+ 17·7
70–75	+ 2·7	− 31·5	+ 3·6	+ 17·1
75–80	+ 11·8	− 23·5	0·0	+ 9·8
80 and over	+ 14·7	− 26·5	− 3·0	+ 8·8

The first noteworthy feature is the excess of young children, or those in the age-period 0–5, in the northern districts, and the defect of the same in the southern districts. The percentage of excess in Auckland is 3·2, and in Wellington 3·5, while in Canterbury the deficiency is 6·6, and in Otago 7·4.

Wellington alone has an excess in the age-period 5–10, but there is not nearly so great a difference between the several districts in this age-period as in the previous one.

Both the northern districts are deficient in both the age-periods 10–15 and 15–20, more particularly Wellington, which has a deficiency of 4·1 per cent. in both periods, while Canterbury has a considerable excess in the age-period 15–20, amounting to 6·8 per cent.

The southern districts have but a slight excess in the next age-period, 20–25, while that of Wellington amounts to 4·9 per cent., Auckland having a deficiency of 4·3 per cent.

For the next five age-periods, including the ages 25–50, both the northern districts have an excess, which is specially marked in the case of Wellington, amounting to no less than 10·7 per cent. for the age-period 35–40, and over 6 per cent.

for each of the periods 30–35 and 40–45. The southern districts, on the other hand, have both a deficiency in each of the first four of these age-periods, amounting to as much as 6·3 per cent. in the case of Otago for the age-period 35–40. In the fifth age-period the southern districts have, however, each an excess, as well as the northern, indicating a deficiency in the smaller provincial districts which are not considered in this paper.

From the age-period 50–55 and onwards the excesses in the southern districts are most marked, but especially in the case of Otago, amounting in this latter case to as much as 16 per cent. for the age-period 60–65, and over 17 per cent. for both the periods 65–70 and 70–75. The deficiency in the case of Wellington is even more marked, amounting to 23·1 per cent. for the age-period 60–65, 32·1 per cent. for the age-period 65–70, 31·5 per cent. for the age-period 70–75, 23·5 per cent. for the age-period 75–80, and 26·5 per cent. for the period 80 and over. This deficiency in the aged in Wellington is one of the most noteworthy features that these tables exhibit, and the contrast with Otago is certainly remarkable. But Wellington is the more recently settled district, and we may expect the same rule to hold with respect to a district as with respect to a colony as a whole—that the more recent is the settlement the smaller is the proportion of the aged.

In these later age-periods Auckland approximates fairly closely on the whole to the average for the whole colony, except in the last two periods of all—namely, those of 75–80 years and 80 years and over; and in these periods that district has a greater excess than any of the other districts, amounting to 11·8 per cent. for the first of the periods and 14·7 per cent. for the other, as against Otago's 9·8 per cent. and 8·8 per cent. respectively, which are the only other excesses in these age-periods, but are themselves considerable.

Considering the provincial districts separately, we may say that the chief features of interest with respect to Auckland are the deficiency of population of the ages 5–25, the excess of the ages 25–50, and the great excess of the very aged of 75 and over. In the case of Wellington the most noteworthy features consist of the considerable excess of population of the ages 20–50 and the great deficiency in population of 50 and over. Canterbury's population has less conspicuous features, the main ones being the considerable deficiency in children of the ages 0–10 and the excess of population of later middle age. Otago shares with Canterbury both of these features, but in addition has a considerable excess of old people of all ages.

Of all these features the most important economically is the preponderance of population of the most vigorous ages of

manhood in the northern districts and the deficiency of the same in the southern. In economic power the population of Wellington, we may remark in particular, is far more nearly equal to that of her sister provinces than mere numbers of population would indicate, and offers a great contrast to Otago especially, with her deficiency both in children and population of early and middle manhood. The same contrast exists to a marked, though not to an equal, extent between the populations of the two northern districts together as compared with those of the southern districts: the population of the north excels that of the south beyond the point its mere excess in numbers might indicate, not only in present economic power, but in capacity for future increase.

I have on other occasions pointed out that statistics of many kinds, applying to different countries or to one country at different times, cannot be properly compared unless the differences in age-distribution of the populations be taken into account. The same applies to the case of these provincial districts. It would be absurd, *e.g.*, to draw any inference from a comparison of the death-rates of Wellington and Otago Districts without first taking into account the great excess of the aged in the one district and the still greater deficiency of the other. Similarly, birth-rates and statistics of health all must be specially prepared with a view to allowing for differences in age-distribution before most comparisons are anything better than worthless. Thus far we have not taken the sexes separately into account.

The Tables III. and IV. give results corresponding exactly to those of I. and II., but for the male population only.

Table III.

Percentages of Male Population of New Zealand and Four Chief Provinces in Quinquennial Age-periods.

Ages.	Percentages.				
	Auckland.	Wellington.	New Zealand.	Canterbury.	Otago.
0–5	11·13	11·42	11·00	10·56	10·22
5–10	10·63	10·80	10·74	10·88	10·43
10–15	10·44	10·12	10·69	11·44	10·55
15–20	9·97	9·99	10·55	11·40	10·98
20–25	9·83	10·90	10·22	10·03	10·22
25–30	8·99	9·19	8·73	8·14	8·54
30–35	7·66	7·94	7·32	6·82	6·98
35–40	6·18	6·80	5·96	5·50	5·50

TABLE III.—*continued.*

PERCENTAGES of Male Population, &c.—*continued.*

Ages.	Percentages.				
	Auckland.	Wellington.	New Zealand.	Canterbury.	Otago.
40–45	5·66	5·71	5·25	5·10	4·92
45–50	4·65	4·90	4·63	4·72	4·75
50–55	3·69	3·70	3·71	3·99	3·92
55–60	3·31	2·85	3·34	3·49	3·67
60–65	3·00	2·36	3·12	3·32	3·60
65–70	2·41	1·61	2·50	2·40	2·98
70–75	1·32	0·82	1·32	1·29	1·61
75–80	0·59	0·40	0·57	0·54	0·64
80 and over	0·39	0·29	0·35	0·34	0·38

This table is illustrated graphically in Plate XLIII.

TABLE IV.

PERCENTAGES of Proportional Excess, relative to the Whole Colony, of the Male Population of the Four Chief Provinces of New Zealand in the Quinquennial Age-periods.

Ages.	Percentages.			
	Auckland.	Wellington.	Canterbury.	Otago.
0–5	+ 1·2	+ 3·8	−4·0	− 7·1
5–10	− 1·0	+ 0·6	+1·3	− 2·9
10–15	− 2·3	− 5·3	+7·0	− 1·3
15–20	− 5·5	− 5·3	+8·1	+ 4·1
20–25	− 3·8	+ 6·7	−1·9	0·0
25–30	+ 3·0	+ 5·3	−6·8	− 2·2
30–35	+ 4·6	+ 4·6	−6 8	− 4·9
35–40	+ 3·7	+14·1	−7·7	− 7·7
40–45	+ 7·8	+ 8·8	−2·9	− 6·3
45–50	+ 0·4	+ 5·8	+1·9	+ 2·6
50–55	− 0·5	− 0·3	+7·5	+ 5·7
55–60	− 0·9	− 14·7	+4·5	+ 9·9
60–65	− 3·8	−24·4	+6·4	+15·4
65–70	− 3·6	−35·6	−4·0	+19·2
70–75	0·0	−37·9	−2·3	+22·0
75–80	+ 3·5	−29·8	−5·3	+12·3
80 and over	+11·4	−17·2	−2·9	+ 8·6

These tables show that the same differences exist in the main between the male populations of the several districts as

between the general populations, but are, as a rule, more marked.

The excess of population of the age of young manhood and middle age in the northern districts is much greater than for the general population, as is also the corresponding deficiency in the southern districts, which increases the force of the remark made above as to the greater economic potentialities of the population of the north.

The excess in Auckland of male population of old age is much less than for both sexes combined, and the deficiency in the Wellington District is substantially greater, so that in both districts females form a greater percentage of the population of old age than of the whole.

Canterbury has a deficiency in males of 65 and over, although taking both sexes together her population approximates to the average.

In Otago the excess of old men is rather more marked than the excess of old people generally.

Tables V. and VI. deal similarly with the female population.

TABLE V.

PERCENTAGES of Female Population of New Zealand and Four Chief Provinces in Quinquennial Age-periods.

Ages.	Percentages.				
	Auckland.	Wellington.	New Zealand.	Canterbury.	Otago.
0–5	12·11	11·95	11·60	10·53	10·68
5–10	11·47	11·77	11·57	10·88	11·38
10–15	11·41	11·21	11·50	11·33	11·45
15–20	11·26	11·20	11·56	12·14	11·66
20–25	10·93	11·82	11·44	11·74	11·66
25–30	9·06	9·62	9·07	9·03	9·05
30–35	7·39	7·77	7·44	7·35	7·65
35–40	5·84	6·19	5·79	5·84	5·57
40–45	4·77	4·87	4·73	4·79	4·61
45–50	3·88	3·81	3·82	3·94	3·80
50–55	3·27	3·16	3·27	3·42	3·29
55–60	2·78	2·30	2·72	2·97	2·96
60–65	2·12	1·73	2·19	2·48	2·56
65–70	1·74	1·21	1·64	1·74	1·89
70–75	0·95	0·69	0·88	0·99	0·96
75–80	0·54	0·38	0·46	0·47	0·47
80 and over	0·40	0·22	0·32	0·32	0·35

This table is illustrated graphically in Plate XLIV.

TABLE VI.

PERCENTAGES of Proportional Excess, relative to the Whole Colony, of the Female Population of the Four Chief Provinces of New Zealand in the Quinquennial Age-periods.

Ages.	Percentages.			
	Auckland.	Wellington.	Canterbury.	Otago.
0–5	+ 4·4	+ 3·0	− 9·2	− 7·9
5–10	− 0·9	+ 1·7	− 1·6	− 1·6
10–15	− 0·8	− 2·5	− 1·5	− 0·5
15–20	− 2·6	− 3·1	+ 5·0	+ 0·9
20–25	− 4·5	+ 3·3	+ 2·6	+ 1·9
25–30	− 0·1	+ 6·1	− 0·4	− 0·2
30–35	− 0·7	+ 4·4	− 1·2	+ 2·8
35–40	+ 0·9	+ 6·9	+ 0·9	− 3·8
40–45	+ 0·8	+ 3·0	+ 1·3	− 2·5
45–50	+ 1·6	− 0·3	+ 3·1	− 0·5
50–55	0·0	− 3·4	+ 4·6	+ 0·6
55–60	+ 2·2	−15·4	+ 9·2	+ 8·8
60–65	− 3·2	−21·0	+13·2	+16·9
65–70	+ 6·1	−26·2	+ 6·1	+15·2
70–75	+ 8·0	−21·6	+12·5	+ 9·1
75–80	+17·4	−17·4	+ 2·2	+ 2·2
80 and over	+25·0	−31·3	0·0	+ 9·4

In the case of the female population the differences between the several districts are again, in the main, similar in character but less marked, as a rule, than in the case of the general population. We may note, however, in the case of Auckland, whereas there is a substantial excess of males of ages 25–45, the female population of those ages differs little from the average. Wellington, on the other hand, has a considerable excess of females of these ages, as well as of males. But Auckland has a considerable excess of females of old-age-pension ages, 65 and over, beginning with 6·1 per cent. for the age-period 65–70 and rising to 25 per cent. for the period 80 and over. Wellington is not as deficient in old females as in old males, but still the deficiency is very great.

Canterbury, while deficient in males of the ages 65 and over, has a considerable excess of females of those ages. Otago alone has a smaller percentage of females than of males in the later age-periods, but still the excess is considerable.

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

THIRTY-FIFTH ANNUAL REPORT.

MEETINGS of the Board were held on the 21st October and the 8th December, 1902, and the 2nd April and the 3rd July, 1903.

Messrs. Tregear, Mason, and Young retired from the Board in compliance with the Act, and were renominated by His Excellency the Governor. The following gentlemen were elected by the incorporated societies as Governors of the New Zealand Institute: Hon. C. C. Bowen, Mr. Martin Chapman, and Mr. S. Percy Smith.

The members now on the roll are—Honorary members, 29; Auckland Institute, 163; Hawke's Bay Philosophical Institute, 62; Wellington Philosophical Society, 150; Philosophical Institute of Canterbury, 69; Otago Institute, 112; Nelson Institute, 17; Westland Institute, 66: making a total of 668.

The volumes of Transactions now on hand are—Vol. I. (second edition), 215; Vol. V., 4; Vol. VI., 8; Vol. VII., 90; Vol. IX., 90; Vol. X., 120; Vol. XI., 20; Vol. XII., 25; Vol. XIII., 25; Vol. XIV., 48; Vol. XV., 150; Vol. XVI., 160; Vol. XVII., 160; Vol. XVIII., 125; Vol. XIX., 150; Vol. XX., 154; Vol. XXI., 85; Vol. XXII., 85; Vol. XXIII., 160; Vol. XXIV., 165; Vol. XXV., 160; Vol. XXVI., 170; Vol. XXVII., 168; Vol. XXVIII., 173; Vol. XXIX., 290; Vol. XXX., 345; Vol. XXXI., 395; Vol. XXXII., 396; Vol. XXXIII., 400; Vol. XXXIV., 400; Vol. XXXV., not yet fully distributed.

The volume just published (XXXV.) contains sixty articles, also addresses and abstracts which appear in the Proceedings. It consists of 623 pages and fifty-four plates. The following is a comparison of the contents of Vol. XXXV. with those of Vol. XXXIV.:—

	1902. Pages.	1901. Pages.
Miscellaneous	305	156
Zoology	77	96
Botany	64	166
Geology	16	86
Chemistry and physics	77	44
Proceedings	29	43
Appendix	55	54
	623	645

The cost of producing and printing Vol. XXXIV. was £452 2s. 6d. for 645 pages and forty-two plates, and that for the present volume (XXXV.) £482 11s. 6d. for 623 pages and fifty-four plates. Both these volumes were entirely turned out at the Government Printing Office.

From the Honorary Treasurer's statement of accounts it appears that the amount received for the year was £964 1s. 3d., including the balance carried forward, and the expenditure £604 12s. 8d., leaving a balance in hand of £359 8s. 7d.

Museum.

There have been 100 entries as additions to the Museum since last report, a list of which will be published in due course. The collections have been regularly cleaned and arranged.

Library.—This is, as far as possible, being kept scientifically up to date.

Meteorological.

The returns of the principal stations for 1902 have been supplied as usual to the Registrar-General to be included in his annual statistics, and the monthly rainfall returns from 180 stations have been regularly supplied to the *Gazette*. The monthly returns for vital statistics have been supplied, and the daily weather exchange by cable is continued between this colony and Australia.

Colonial Time-ball Observatory.

Mr. Thomas King, the officer in charge, reports as follows: "The work of the time service has proceeded as usual. Regular observations for the determination of clock-error have been taken, and exact time has been distributed throughout the colony as heretofore. The clocks have maintained very good rates. The time-ball at Wellington has been dropped daily (Sundays excepted), and galvanometer signals have been sent hourly from the Observatory in the manner described in previous reports. During the stay of the relief ship 'Morning' at Lyttelton, prior to her start for the antarctic regions, signals were frequently transmitted to her by special telegraph-wire direct from the Observatory to the officers' cabin, and the vessel was thus enabled to rate her chronometers accurately for some days before the beginning of her important voyage. The value 11h. 39m. 5·3s. E. has, since the beginning of 1903, been assumed as the longitude of the Observatory in computing time. This longitude has, of course, been for very many years recognised as the correct one; but owing to the fact that the old value—viz., 11h. 39m. 9·3s. E.—was retained on the Admiralty charts it was not deemed wise to

employ the amended longitude for the purposes of the time service, as the advantage from a navigator's point of view of having a value in harmony with the one shown on the charts was obvious. The Admiralty, however, has at last found it practicable to adopt the true longitude in one or two of its harbour-charts; and, although in view of the smallness of the error involved and of the expense of regraduating a large series of charts the Admiralty has no present intention of amending the majority of the coastal charts, this partial recognition of the corrected longitude has opened the way for a reconsideration of the matter, and, after submission of the point to the Hydrographer to the Admiralty, the value 11h. 39m. 5·3s. has, with that official's entire concurrence, been adopted as the one for use in calculations necessary for time-determination. The whole question is discussed at length in a paper which I had the honour of reading before the Wellington Philosophical Society on the 18th March, 1903 ('On the Longitude of the Colonial Observatory, &c.'), and I would respectfully ask reference to that paper for details of the subject."

The balance-sheet, duly certified, is appended, and the schedules and correspondence will be published with the report in the usual pamphlet form.

JAMES HECTOR, Manager.

Approved.—MARTIN CHAPMAN, Chairman.—3rd July, 1903.

NEW ZEALAND INSTITUTE ACCOUNTS FOR 1902–3.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
Balance from last year	408	2	11	Printing Vol. XXXV...	482	11	6
Vote for 1902–3 ..	500	0	0	Expenses of library ..	20	0	0
Contribution from Wellington Philosophical Society	17	10	0	Expenses, "Maori Art"	36	8	8
				Postages, foreign volumes	3	17	6
Sale of "Maori Art" ..	37	7	4	Expenses, International Catalogue	15	0	0
Sale of Transactions ..	1	1	0	Miscellaneous items ..	46	15	0
				Balance	359	8	7
	£964	1	3		£964	1	3

Examined and found correct.

MARTIN CHAPMAN, Acting-Treasurer.

3rd July, 1903.

COLONIAL TIME-BALL OBSERVATORY.

Mr. Thomas King, the officer in charge, reports as follows:—

The clocks have kept satisfactory rates throughout the year, and the instruments are in good order. There are no

points calling for special remark in connection with the regular time service, the duties of which have had attention as heretofore.

Towards the end of 1903 I had pleasure in co-operating with Mr. Otto J. Klotz, Government Astronomer of Canada, in the New Zealand section of the very important work which has been undertaken by the Dominion Government in the shape of a determination of the longitudes of a number of fundamental points on the route of the Pacific cable. At the instance of the Department of the Interior, Ottawa, Mr. Klotz carried a chain of longitude-work from Greenwich to the Pacific coast of Canada by means of the telegraph-line, and thence to Australia and New Zealand over the new Pacific cable. The station in New Zealand the position of which he sought to fix in the course of this survey was Doubtless Bay, in the northern part of the Provincial District of Auckland, a temporary observatory being erected by him there near the spot at which the cable comes ashore. It was necessary for his purpose that a meridian distance should be ascertained between his observing-station and some spot in New Zealand the longitude of which had already been well determined, and Wellington Observatory was naturally selected as best fulfilling this requirement. By direction of the Hon. the Postmaster-General, special telegraphic communication was established between the observatories at Wellington and Doubtless Bay. Very full sets of transit observations were simultaneously taken on suitable nights by Mr. Klotz at Doubtless Bay and by myself at Wellington, the stars selected being chosen with a view both to the accurate determination of our respective local sidereal times and to the elimination of our instrumental errors. The nights on which these observations were secured were those of the 6th, 7th, 10th, 11th, 12th, 17th, and 18th December, the work beginning soon after dark and ending after midnight. On several of these evenings we succeeded in observing twenty stars per night, of which sixteen were ordinary "clock stars" and four were circumpolar stars for the determination of the azimuth and collimation errors of the transit instruments. The Wellington and Doubtless Bay clocks were automatically compared on the same nights by means of the telegraph and chronograph, the clocks being placed on the main line for several minutes at a time so as to record at once on both chronographs. Thus the seconds of the Wellington sidereal clock were simultaneously pricked off on the Wellington and on the Doubtless Bay chronographs, and the seconds of the Doubtless Bay sidereal clock were in like manner recorded on the Doubtless Bay and Wellington chronographs. By sending the signals in *both* directions any error due to wave and armature time on the

telegraph-line was got rid of. After the completion of the work Mr. Klotz came to Wellington and conducted with me at the Observatory a series of observations for the purpose of ascertaining the difference between our respective personal equations. He also thoroughly satisfied himself as to the adjustments of the transit instrument, with the view of taking into account its several "constants of correction"; and he similarly tested the striding-level. Details of my transit-observations and level-readings, with the original chronograph records and my full "scalings" of the same, and also a report on the work, were handed to Mr. Klotz in January last, and will in due course be incorporated in his general report on the survey. Copies of these documents are attached hereto; but presumably they need not be printed, as the Canadian report, which will cover the whole ground, will be forwarded to the colony by Mr. Klotz as soon as it is published. In view of the fact that the use of the siphon recorder in cable-work has greatly increased the accuracy attainable in transmitting time-signals for longitude purposes, it will be of interest to see how Mr. Klotz's final results compare with those obtained in 1886, when a very elaborate series of determinations was effected by cable from Greenwich in the opposite direction (namely, eastwards), across India to Madras, and from that point by intermediate stations to Australia.

On New Year's eve, at the request of the United States Government, a set of signals was received from the United States Naval Observatory, Washington, for the purpose of ascertaining the minimum time in which a signal could be repeated over a long distance from station to station by cable. Owing to hasty preparation the test was only partially successful; but the last signal sent would appear to have reached Wellington Observatory from Washington in about four seconds. It was transmitted from Washington to Greenwich in 1·3s., and to Sydney in about 3·5s. Rear-Admiral Chester, Superintendent of the United States Naval Observatory, in a letter addressed to Mr. W. Gray, Secretary of the Post and Telegraph Department, expresses the opinion that, considering the short notice given, the cable and telegraph operators did very well on this occasion. The experiment was an extremely interesting one, and there is a possibility that Admiral Chester may propose a repetition of it at some convenient future time.

March, 1904.

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *3rd June, 1903.*

Professor Easterfield, President, in the chair.

New Members.—G. M. Mason, J. Lewis, A. H. Gore, C. Freyberg, and W. F. Robinson.

Before proceeding with his address, Professor Easterfield thanked the members for electing him to the position of President for the ensuing year. He would endeavour to justify their selection.

The President then read a notice (prepared by Sir James Hector) of the late W. T. L. Travers, F.L.S., which referred to his long connection with the Society, and concluded by moving as follows, members standing during the reading of the motion:—

That a formal entry of the foregoing notice be made on the records of the Society, which sets forth a recognition of the great services which have been rendered to science by the late W. T. L. Travers, F.L.S., and that copies be forwarded, with an expression of sympathy, to his relatives.

Reference was also made to the loss sustained by the death of two prominent members of the Society—viz., Major-General Schaw and the Hon. Dr. Grace.

Professor Easterfield then delivered his presidential address, "A Hundred Years in the History of a Theory," which was listened to with great attention.

On the motion of Mr. Hogben, a hearty vote of thanks was given to Professor Easterfield for his address.

Second Meeting: *1st July, 1903.*

Professor Easterfield, President, in the chair.

Mr. H. N. McLeod read a paper, illustrated by photographs, on "Caves and Water-passages in the Greymouth District."

He had made an exploration, necessarily hasty, of some of these caves, and described the result of his investigation. Originally, he thought, these caves were formed by percolation of water from above—a view confirmed by the discovery of the seeds of *Phormium tenax* clinging to the sides. This process still went on. Their general trend was downwards, and they served as overflow-channels carrying the flood-waters by subterranean passages to the Grey River.

Sir James Hector said he knew the caves, which were of interest on account of fossil remains recovered from them, including bones of the Paleudyptes, an extinct penguin over 7 ft. high. The limestone formation in which these caves occurred overlaid the great coal-measures of the Grey district. He described the remarkable fault in the limestone range, which had developed into a rift 700 ft. deep, through which, in ancient times, the waters of the Grey had been diverted from their former channel.

Mr. C. E. Adams exhibited some of the powers of a calculating-machine by a Russian inventor, which possessed remarkable powers of multiplying, dividing, summing up successive totals, and extracting roots.

Sir James Hector said that twenty-five years ago Mr. Leonard Stowe, Clerk to the General Assembly, devised and patented a very similar piece of mechanism. He still possessed the original model.

The President said the machine illustrated what a purely mechanical operation computation really was. The amount of unnecessary drudgery saved by a machine such as this to those who had to deal continually with large figures, besides its freedom from liability to error, made it exceedingly valuable. It was an interesting fact that many illustrious mathematicians were deficient in the mechanical skill necessary to compute correctly. He mentioned several great names, including Helmholtz, who, as he would insist on doing his own blackboard-work when lecturing, usually made an error in his first attempt at multiplication, and spent a good part of the rest of his time in trying to find where it occurred.

The President, Professor Easterfield, exhibited a tool in the new "high-speed steel," forwarded by a friend in Sheffield.

He said that the new steel, which promised to bring about vast industrial changes, as it could do such work as the turning of propeller-shafts at five times the rate of the best ordinary steel, owed its quality to the admixture of a small but definite proportion of tungsten, and possibly of chromium, and also to a difference in manufacture. Ordinary steel was spoiled if heated beyond a dull red; the new steel was heated to whiteness, and cooled simply by a steady blast of cold air. Water was necessary in grinding ordinary steel; it must not be used with the new, which was ground dry on an emery wheel, red-hot sparks flying off the while. If overheated in working steel tools became useless; the new steel tools had been shown at work hot with friction, and swiftly winding off blue shavings from a rotary shaft. He was pleased to say that this vast improvement had been brought about by British firms.

Sir James Hector remarked that scheelite and wolfram, the ores yielding tungsten, were abundant in New Zealand.

Sir James Hector explained a number of natural-history exhibits, including the rare South Pacific cod, a stray specimen of which is sometimes stranded at Island Bay after a gale; and a German owl, only distinguishable from the morepork of Australasia by a lighter colour in the plumage of the back.

Sir James Hector said that, with the permission of the meeting, he would like to make a few remarks. He said,—

It is thirty-five years since I was first connected with this Society. I now have to leave. I suppose I shall never have the opportunity of meeting you again. It is a great strain. But these things cannot be avoided. We grow old, and have to leave the field to younger and better men. I do

feel it my duty to express my thanks for the kind manner in which you have always sustained me in the work I have had to do. It has sometimes been hard and cross-grained, but I have always met with the greatest kindness and appreciation of such merit as the work I have contributed has possessed. I ask you, sir, to receive my thanks to the Society.

The President, Professor Easterfield, said: Ladies and Gentlemen, Sir James Hector has just alluded to his long connection with this Society, and has referred to the fact that he is about to leave us. The Society sincerely hopes that on many future occasions it may have the privilege of his presence and assistance. He is about to leave us on a trip to Canada, but we look forward to only a temporary separation from our old and trusted friend. I feel sure that we all look forward earnestly to the time when we shall have him back among us, refreshed by rest and change of scene, and with his health and old energy restored. The strain upon him of the Institute and its duties has for some time past been too severe. I am only expressing the feelings of all present when I say that we are looking forward with pleasure to the time when we shall welcome him among us once more.

THIRD MEETING: *5th August, 1903.*

The President, Professor Easterfield, in the chair.

Mr. Martin Chapman proposed, and Mr. Hogben seconded, That the President be instructed to expend the sum of ten guineas in a suitable memento in appreciation of the services of the late Secretary.—Carried.

Papers.—1. "On the Fallacies of the Metric System," pt. i., by R. Coupland Harding.

2. "On the Occurrence of certain *Lepidoptera* in Southland," by A. Philpott; communicated by G. V. Hudson, F.E.S.

Exhibits.—1. Brown trout, weight 29 lb. (kindly lent by the Superintendent, Tourist Department).

2. Esquimaux camelito or parkee (rain-coat).

3. New Zealand weta (*Deinacrida thoracica*).

FOURTH MEETING: *2nd September, 1903.*

The President, Professor Easterfield, in the chair.

Presentation.—In pursuance of a resolution passed at the last meeting of the Society, the President presented to Mr. R. B. Gore, the late Secretary of the Society, some handsome pieces of plate, bearing an inscription indicating that they are a memento of Mr. Gore's services to the Society from 1873 to 1903. In a letter of thanks Mr. Gore expressed his appreciation of the gift and the good wishes for his restoration to health, which, he regretted to say, was still very unsatisfactory.

Papers.—1. "Notes on an Insect found in some Hot Springs at Taupo," by J. W. Poynton.

The insect, which is present in large quantities all the year round, is about half the size of a house-fly, but more slender and shapely, and is black in colour. It apparently builds natural incubators, and is said to be an undescribed species. Mr. Poynton suggested a number of questions for study by competent scientists, including the great possibility of the important part these insects and their habits have played and are playing in the formation of terraces.

In the course of a discussion Professor H. B. Kirk expressed the opinion that Mr. Poynton's observations were of great scientific and economic value. If the suggestion as to the formation of terraces was correct, there was at once presented the possibility of importing these flies to places where they did not now exist. In regard to insect and animal life in hot springs, Professor Kirk said there was no doubt that fish at Rotorua, for instance, went into water quite hot enough to cook them, and though they were not cooked they grew coarse and ugly.

Professor Easterfield thought the Research Fund might well be devoted to further investigation of such an important matter as Mr. Poynton's suggestion.

2. "On Rimu-resin," by Professor Easterfield and B. C. Aston.

This paper included the results of some preliminary investigations by the Professor and Mr. B. C. Aston, Chemist to the Agricultural Department. The resin, when chewed, has a very bitter taste, and is very much simpler than the complicated kauri-resin. It dissolves very easily in alcohol; and if water be cautiously added to the solution a beautiful crystalline substance comes out, which is an acid, and which has been given the name of "rimuic acid." This melts at 192° Centigrade. The resin consists of 75 per cent. of rimuic acid, and the greater part of the remainder, after the acid has been precipitated, consists of a gum which up to the present the investigators have not further investigated, while the pink colouring is a vegetable bitter. Most of the pines when their bark is cut weep resin, but the rimu, he was informed, did not do so, as it had its resin right in the heart of the wood. The Professor went into a detailed explanation, and said it appeared that the chemistry of this resin was not so complicated as it was believed by many to be. He hoped to go into the subject of kauri-resin when he had disposed of the rimu.

In the ensuing discussion the speakers emphasized the importance of the investigations being made.

Mr. Gerald Fitzgerald quoted actual experience to show that the rimu did not possess the preservative qualities it was supposed to possess; but Mr. Poynton held an opposite opinion of the value of the resin as a preservative, based on his own observations.

Exhibits.—1. Birds from South Africa.

2. Moa-bones.

3. Bill of hornbill.

Fifth Meeting: *7th October, 1903.*

The President, Professor Easterfield, in the chair.

New Members.—Rev. D. C. Bates and Mr. M. H. Browne.

Papers.—1. "On the Fallacies of the Metric System," pt. ii., by R. Coupland Harding.

2. "On Adjustment of Triangulation by Least Squares," pt. ii., by C. E. Adams, B.Sc.

3. "Notes on Southern *Lepidoptera*," by Alfred Philpott.

4. "Molecular Association and the Arrangement of Atoms in Space," by C. W. Robertson.

Exhibits.—1. Corean duck.

2. Nails found in gizzard of duck.

3. Cast of diorite *mere* (original stolen from Maori House on the 12th September, 1903).

4. Rabbit with peculiar growth of teeth.

5. Green linnets (male and female).

6. New Zealand tree-lizard.

7. Petrological microscope (Mr. Adams).

SIXTH MEETING: *4th November, 1903.*

The President, Professor Easterfield, in the chair.

Papers.—1. "Notes on some Curiously Carved Maori Calabashes," by Dr. Newman (with exhibits).

The exhibits consisted of two fine specimens of calabashes recently acquired by the writer, one, unfortunately, broken in transit from the Wairarapa district. Apart from their unusual size, they were remarkable on account of their being fitted with elaborately decorated collars or necks, carved out of matai wood. As their use was for the preservation of birds, &c., in their own fat, they were very greasy, within and without. The larger, when filled, would weigh nearly a hundredweight. Each was fully equipped with the original *kete* (called "kit" by the pakeha), an open net of phormium leaves gathered into a handle above for convenience of carriage.

Dr. Newman explained the use of the *hue*, or calabash gourd, among the old natives. Some with carved collars were still to be found in the Urewera country, but were rare and highly prized. These particular specimens had been found in an outhouse in the Wairarapa district, the modern native in contact with civilisation preferring kerosene-tins. The Maori owner said they had belonged to his grandfather, a chief, whom he remembered as nearly a century old. All the Museum specimens appeared to have lost the carved collar. It was called by the Maoris *tuki* or *kohamohamo*. The words might be synonymous, or might refer to different varieties; they were not in existing dictionaries. Calabashes had been much neglected by collectors. Those now before the meeting were used only by chiefs, and formed the central object at feasts, containing, as they did, the choicest delicacies for the invited guests. The Maoris said they had brought the seed of the calabash from "Hawaiki," and that no such large gourds as those of olden time could now be grown.

The President and other members expressed their indebtedness to Dr. Newman for his paper, and he, in the course of his reply, added further information on the subject.

2. "Notes on Aconitic Acid," by James Bee; communicated by Professor Easterfield.

The writer had been investigating this acid (characteristic of the aconite plant, or monk's-hood, but which in the arts is obtained from citric acid), and had discovered some interesting reactions—one almost unique in chemical experience—which were described. By an accidental oversight in preparing the acid—boiling a solution for ten hours instead of five—he found he had obtained an acid of quite different character. This, submitted to the usual tests, proved to be diconic acid. This discovery, Professor Easterfield explained, was of importance. Diconic acid, owing to the tedious process necessary for its production—long boiling in closed tubes, under pressure, having been necessary—had been little studied. Mr. Bee had now opened the path for any one who wished to investigate the subject, as the acid could now be readily prepared in open vessels, and in any quantity required.

3. "Notes on some New *Lepidoptera* from Lake Wakatipu," by G. V. Hudson, F.E.S. (with exhibits).

Exhibit.—Professor Easterfield exhibited a hot-air engine, and explained its use.

SEVENTH MEETING: *17th December, 1903.*

The President, Professor Easterfield, in the chair.

Governors of New Zealand Institute.—On the motion of Mr. G. Hogben, seconded by Mr. A. McKay, Professor Easterfield and Mr. Martin Chapman were appointed to represent the Society on the Board of Governors of the New Zealand Institute.

Paper.—"On Anatomy of *Paryphanta fumosa*," by R. Murdoch.

ANNUAL MEETING: *13th April, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Alfred Cockayne.

The annual report and balance-sheet was read and approved.

The receipts were given as £176 14s. 2d., and the expenditure £103 5s. 2d., leaving a balance in hand of £73 9s.

The Research Fund—a fixed deposit in the bank—now amounts to £38 15s. 9d., which increases the credit balance to £112 4s. 9d.

ELECTION OF OFFICERS FOR 1904.—*President*—Professor Easterfield; *Vice-Presidents*—G. Hogben, M.A., and E. Tregear, F.R.G.S.; *Council*—R. C. Harding, G. V. Hudson, F.E.S., Professor H. B. Kirk, C. E. Adams, B.Sc., Sir James Hector, F.R.S., Martin Chapman, and C. T. Richardson.

Papers.—1. "On the Occurrence of Starch in Timber," by Professor Kirk.

2. "On the Constitution of some Resin-acids," by Professor Easterfield.

AUCKLAND INSTITUTE.

FIRST MEETING: *8th June, 1903.*

Professor A. P. Thomas, President, in the chair.

New Members.—G. George, H. A. Gordon, and H. T. Pycroft.

The President delivered the anniversary address.

SECOND MEETING: *22nd June, 1903.*

Professor A. P. Thomas, President, in the chair.

Mr. J. H. Howell, B.Sc., delivered a popular lecture, illustrated by numerous experiments, on "The Spectroscope, and its Use in Scientific Research."

THIRD MEETING: *6th July, 1903.*

Professor A. P. Thomas, President, in the chair.

New Members.—H. Cummings and H. Kronfeld.

Papers.—1. "Note on a Branched Cocoanut Palm," by R. B. Walrond.

The author stated that during the recent parliamentary excursion to the Cook Islands, which he accompanied, he was informed of a branched cocoanut-tree growing on the Island of Mangaia. Knowing the interest which is attached to branched palms, he visited the locality and secured some photographs of the tree, which he exhibited to the meeting.

2. "On an Abnormal Growth of *Phormium colensoi*," by the Right Rev. W. L. Williams.

3. "A Note on Drawing for Competitions," by Professor H. W. Segar.

4. "Note on the Veracity of the Age-returns in the Census of 1901," by Professor H. W. Segar.

5. "A Comparison of the Age-distribution of the Population of the Four Chief Provincial Districts," by Professor H. W. Segar.

6. "On certain Statistics respecting the Trend of English Trade," by Professor H. W. Segar.

FOURTH MEETING: *20th July, 1903.*

Professor A. P. Thomas, President, in the chair.

New Members.—H. C. Clark, W. H. Hamer, W. Henry, V. J. Larner, J. R. Lundon, and R. Stopford, M.D.

Professor F. D. Brown delivered a popular lecture, illustrated by numerous experiments, on "Radiation."

FIFTH MEETING: *3rd August, 1903.*

Professor A. P. Thomas, President, in the chair.

Papers.—1. "On the Maori Method of preparing and using *Kokowai*," by Archdeacon P. Walsh.

Specimens of the stone slabs and rubbers using in preparing *kokowai* were exhibited in illustration of the paper, and presented to the Museum by the author.

2. "On the Interferometer," by E. V. Miller.

SIXTH MEETING: *17th August, 1903.*

Professor A. P. Thomas, President, in the chair.

The Rev. H. Anson delivered a popular lecture entitled "Mr. Gladstone."

SEVENTH MEETING: *7th September, 1903.*

Professor A. P. Thomas, President, in the chair.

New Members.—W. S. Lyell, E. P. Turner, and N. A. Winter.

Papers.—1. "Maori Medical Lore," by Dr. W. H. Goldie.

2. "Maori Marriage Customs," by Elsdon Best.

EIGHTH MEETING: *21st September, 1903.*

Professor A. P. Thomas, President, in the chair.

New Member.—Dr. Neill.

Mr. E. K. Mulgan delivered a popular lecture, illustrated with numerous limelight views, on "The Northern Wairoa."

NINTH MEETING: *29th February, 1904.*

Dr. Roberton, Vice-President, in the chair.

New Member.—J. L. Young.

Paper.—"On the Fossils of the Waitemata and Papakura Series," by E. Clarke.

Abstract of Annual Report.

In accordance with the rules of the society, the Council have now to present to their members their thirty-sixth annual report on the financial and general condition of the Institute, and its progress during the past year.

Members.—Sixteen new members have been elected during the year. On the other hand, fourteen names have been withdrawn from the roll, six from death, four from resignation, and four from non-payment of subscription for more than two consecutive years. There is thus a net gain of two, the number on the roll at the present time being 165. The members removed by death are Messrs. A. D. Austin, W. Berry, A. Buckland, J. Chambers, L. Cussen, and J. Hume, nearly all of whom have been associated with the Institute for many years.

Finance.—For full information respecting the financial position of the Institute reference should be made to the balance-sheets appended to this report, but the following abstract may be useful: The total income of the Working Account, omitting the balance of £59 18s. 6d. on hand at the commencement of the year, has been £872 18s. 7d. This shows a slight increase on the amount realised last year, which was £851 14s. 8d. Examining the separate items, it will be seen that the Museum Endowment, which now constitutes one of the chief sources of the revenue of the society, has yielded £344 13s. 4d., the amount for the previous year being £375 15s. 7d. The invested funds of the Costley bequest have contributed £357 10s., the sum for 1902–3 being £325 13s. 9d. From the members' subscriptions £131 5s. has been received, showing a reduction of £10 10s. on the amount for last year. The total expenditure has been £809 7s. 10d., leaving a balance of £123 9s. 3d. in the Bank of New Zealand. The Council are glad to report that the invested funds of the society are in a satisfactory state. The total amount at the present time is £16,226 12s. 5d., showing an increase of £2,230 6s. 3d. during the year. The addition consists of the Mackechnie bequest of £2,000 for the endowment of the library, presently to be alluded to, and a sum of £230 derived from the sale of certain portions of the landed endowment of the Museum.

Meetings.—Nine meetings have been held during the year.

Museum.—With the exception of a short period devoted to cleaning and rearrangement, the Museum has been open daily to the public throughout the year during the usual hours—from 10 a.m. to 5 p.m. on week-days, and from 2 to 5 p.m. on Sundays. The attendance of visitors has been satisfactory. The register kept by the janitor shows that on Sunday afternoons 13,377 people entered the building, being an average of 257 for each Sunday. The greatest attendance was 378 on the 23rd August; the smallest 80 on 5th July. On the five chief holidays of the year—New Year's Day, Good Friday, Easter Monday, King's Birthday, and Boxing Day—the total attendance was 1,181, or an average of 236 for each day. On ordinary week-days the visitors can only be occasionally counted; but the average attendance is certainly not less than 100 per day. With the number previously given, a calculation on this basis would make the total attendance to be 45,360. Last year the number was estimated at 43,956. It is worthy of remark that the average attendance on Sunday afternoon, when the Museum is only open for three hours, is in excess of the average for the chief holidays, when the Museum is open for the whole day.

In the report for the previous year the Council stated that an application had been made to the Government for a pound-for-pound subsidy equivalent to the amount (£1,000) subscribed by the citizens of Auckland for the purchase of the Mair Collection of Maori Antiquities. During the

recent session of Parliament the matter was again revived, and warmly advocated by the members for the City of Auckland and the Suburbs, with the result that the Government consented to place a vote of £1,000 on the supplementary estimates. This was agreed to by Parliament, and the Premier, in a recent interview with the Council, engaged that the money would be at once made available for defraying the cost of an annexe to the Maori Hall. Under these circumstances, the Council have arranged for the erection of a hall 50 ft. square, to occupy the vacant space between the Statue Hall and the Main Hall. One portion of the building will contain the Maori carved house, Rangitihi, which has been in the possession of the Museum for some time, but which for want of funds has not yet been erected; the remainder will form an exhibition gallery for ethnological specimens. In structural details the new building will agree with the Maori Hall, the walls and floor being of brick or concrete, and the roof of iron and glass. The cost of erection will absorb the whole of the grant, so that after its completion other arrangements will be required for putting up the Maori house, and for the show-cases and other fittings required for the exhibition gallery. But the acquisition of the building alone will be a distinct advantage, and one upon which the Museum may be safely congratulated.

The chief additions made to the Museum during the year have been in the ethnographical department. Special mention may be made of an interesting series of Moriori stone weapons, purchased from Mr. R. Shand, late of the Chatham Islands; of some Maori kites, kindly obtained for the Museum by Mr. Elsdon Best, of Ruatahuna; of a collection of Australian stone weapons, forwarded in exchange by Mr. J. Williamson, of Victoria; and of a set of prehistoric flint implements from Central Africa, presented by Colonel Seton-Karr. The Council have frequently mentioned the slow progress made by the zoological side of the Museum, so that they have some little satisfaction in stating that there is every prospect of an important addition being made to this department at no distant date. It will be in the recollection of members that the late Mrs. Mackechnie bequeathed a sum of £500 to be expended, at the discretion of her executor, in suitable additions to the Museum. This gentleman has intimated his desire that the bequest should be expended in the purchase of stuffed groups of the larger animals, set up in the best style of taxidermy, and protected by suitable plate-glass cases. Preliminary inquiries are now being made, and it is hoped that an order for the first of the groups will soon be taken in hand.

Library.—The Council have but little to report under this head. Few purchases of books have been made, but a considerable expenditure has been incurred in binding the arrears of scientific journals, publications of societies, &c. The usual exchanges and presentations from foreign societies have been received, together with the magazines and periodicals subscribed to by the Institute, a list of which will be found on another page. The most important donation of books received consists of forty-eight volumes of books dealing with the history of India, formerly the property of the late Bishop Cowie, and presented to the library in remembrance of him by his family. The Mackechnie bequest of £2,000, the annual interest on which must be applied solely to the purchase of books, has been duly paid over and invested. In the future it will provide a regular fund for the augmentation of the library, and will enable the Council to extend its usefulness in a manner which could not be attempted with the slender funds to be spared from the ordinary revenue of the society.

Little Barrier Island.—The management of the Little Barrier Island as a reserve for the preservation of the avifauna of New Zealand still remains in the hands of the Institute, the Government contributing

an annual grant of £200 to cover the necessary expenses. The Curator, Mr. Shakespear, reports that no attempt has been made to molest the birds, and that no unauthorised persons have landed on the island. The Council entertain no doubt that if a resident guardian is maintained on the island it will long remain a secure home for a considerable portion of the avifauna of New Zealand.

Election of Officers for 1904.—*President*—Professor A. P. Thomas, F.L.S.; *Vice-Presidents*—E. Roberton, Esq., M.D., and J. Stewart, Esq., M.I.C.E.; *Council*—Professor F. D. Brown, C. Cooper, Esq., H. Haines, Esq., F.R.C.S., J. H. Howell, B.Sc., J. Kirker, Esq., E. V. Miller, Esq., T. Peacock, Esq., D. Petrie, Esq., J. Reid, Esq., Professor H. W. Segar, J. H. Upton, Esq.; *Trustees*—Professor F. D. Brown, T. Peacock, Esq., J. H. Upton, Esq.; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—W. Gorrie, Esq.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

FIRST MEETING: *6th May, 1903.*

Dr. Charles Chilton, President, in the chair.

New Members.—Messrs. E. G. Hogg, E. Cuthburt, Rev. A. C. Carrington, and Dr. Finch.

Address.—The retiring President, Mr. J. B. Mayne, delivered his address on "Bacteria and Fermentation," and illustrated it by diagrams and specimens.

SECOND MEETING: *3rd June, 1903.*

Dr. Chilton, President, in the chair.

New Members.—Messrs. M. G. Wallich and L. Birks.

Resolution.—The President proposed, and Captain F. W. Hutton seconded, and it was unanimously resolved,—

That the Philosophical Institute of Canterbury, hearing that Sir James Hector is retiring from his official position as Director of the Geological Survey and Manager of the New Zealand Institute after thirty-five years of service, desires to express its appreciation of the skilful and efficient manner in which he has discharged the many varied duties of his office during his long term of service. As Manager of the New Zealand Institute and Editor of its Transactions he has had a most arduous and difficult task to perform, and one calling for a wide knowledge on a great variety of subjects, and the thirty-five volumes of the Transactions form a permanent record of the able manner in which he has performed the work allotted to him. The Institute trusts that he may still be spared for many years to devote his leisure to the further advancement of science.

Address.—Mr. E. G. Hogg delivered an address on "The Falls of Niagara—a Geological Study," illustrating it with a large number of lantern-slides.

THIRD MEETING: *1st July, 1903.*

Dr. Chilton, President, in the chair.

New Members.—Mrs. A. Anderson and Messrs. J. R. Charlton, C. Carmichael, and A. Kaye.

Address.—Mr. R. Nairne delivered an address, illustrated by lantern-slides, on "Horticulture in New Zealand."

FOURTH MEETING: *5th August, 1903.*

Dr. Chilton, President, in the chair.

New Members.—The Right Rev. Bishop Grimes and Messrs. W. E. Burley, W. Colbatch, W. R. Haselden, and W. H. Moyes.

Address.—Mr. A. R. Craddock gave an address, illustrated by experiments and lantern-slides, on "The Induction of Electric Currents."

FIFTH MEETING: *2nd September, 1903.*

Dr. Chilton, President, in the chair.

New Member.—Dr. Hugh Acland.

The President congratulated Dr. L. Cockayne on the honour which had been conferred upon him by the Ancient University of Munich.

Address.—Professor W. P. Evans delivered an address, illustrated by experiments and lantern-slides, on "The Liquefaction of Gases."

SIXTH MEETING: *7th October, 1903.*

Dr. Chilton, President, in the chair.

New Members.—Messrs. P. Trolove and C. J. Williams.

Address.—Mr. R. Speight gave an address, illustrated by diagrams, on "A Chapter in Canterbury Geology."

SEVENTH MEETING: *4th November, 1903.*

Dr. Chilton, President, in the chair.

Papers.—1. "A Botanical Excursion during Midwinter to the Southern Islands of New Zealand," by Dr. L. Cockayne.

2. "Plants naturalised in the County of Ashburton," by Mr. W. W. Smith.

3. "Note on a Dyke at Nugget Point," by Mr. R. Speight.

4. "A Species of *Ixodes* parasitic on the Grey Duck," by Dr. C. Chilton.

5. "Revision of the New Zealand Members of the *Phorocera*," by Captain F. W. Hutton, F.R.S.

6. "On the Occurrence of *Centrolophus* in New Zealand," by Captain F. W. Hutton, F.R.S.

7. "Description of a New Fish," by Captain F. W. Hutton, F.R.S.

8. "On the Occurrence of the Curlew-Sandpiper in New Zealand," by Captain F. W. Hutton, F.R.S.

9. "Two New Flies," by Captain F. W. Hutton, F.R.S.

10. "On a New Weta from the Chatham Islands," by Captain F. W. Hutton, F.R.S.

11. "Description of a New Blowfly from Campbell Island," by Captain F. W. Hutton, F.R.S.

Exhibits.—The following exhibits were laid before the meeting:—By Mr. E. G. Hogg: Some symmetrical nodules from Tasmania. By Mr. T. W. Adams: A branch of laburnum having both purple and yellow flowers. By Dr. Coleridge Farr: The trace of the vertical-force magnetograph during the recent magnetic storm.

SPECIAL MEETING: *25th November, 1903.*

Dr. Chilton, President, in the chair.

The meeting was called to amend the laws in conformity with "The New Zealand Institute Act, 1903."

Captain F. W. Hutton, F.R.S., and Dr. Chilton were elected to represent the Institute on the Board of Governors of the New Zealand Institute.

ANNUAL MEETING: *25th November, 1903.*

Dr. Chilton, President, in the chair.

New Member.—Mr. G. W. Kirkaldy.

ABSTRACT OF ANNUAL REPORT.

The Council met twelve times since the previous annual meeting.

The retirement of Sir James Hector, K.C.M.G., from the position of Manager of the New Zealand Institute caused the Council to consider what changes were desirable in the constitution of the New Zealand Institute. After correspondence with the other institutes, and a deputation having waited upon the Colonial Secretary, the Council drafted a Bill, which, with few amendments, has since become law.

The "Index Faunæ Novæ-Zealandiæ" is nearing completion, and the first bound copy was laid on the table.

The library has been kept in a state of efficiency.

The thanks of the Institute are due to the Hon. C. C. Bowen, who has represented the Institute on the Board of Governors of the New Zealand Institute, and to Mr. G. E. Way, F.I.A.N.Z., for his services as honorary auditor.

The balance-sheet for the period from the 1st January, 1903, to the 31st October, 1903, shows that £42 10s. has been received for members' subscriptions, £23 4s. 3d. has been spent in the purchase of books and periodicals for the library, and £10 11s. 9d. for binding compieted volumes. The credit balance on the 31st October was £76 14s. 9d., but this includes £50 from Captain Hutton for the purchase of 100 copies of the "Index Faunæ Novæ-Zealandiæ." The No. 2 Account, "Life Members' Subscriptions," shows a credit balance of £82 6s. 2d., the interest on which at 3½ per cent. accrued on the 21st November, 1903.

The number of members of the Institute is eighty-five and two associates, and the average attendance at the meetings of the past year has been thirty-nine.

Six addresses (enumerated above) and twelve papers have been read before the Institute during the year. The papers may be classified as—zoology, 8 papers; botany, 2; and geology, 2.

Election of Officers for 1904.—*President*—Professor Charles Chilton, D.Sc., M.A., M.B., &c.; *Vice-Presidents*—Mr. J. B. Mayne, B.A., and Mr. R. Speight, M.A., B.Sc.; *Honorary Secretary*—Dr. Coleridge Farr, A.M.I.C.E.; *Honorary Treasurer*—Professor Charles Chilton, M.A., M.B., D.Sc.; *Council*—Mr. R. M. Laing, M.A., B.Sc., Captain F. W. Hutton, F.R.S., President New Zealand Institute, Dr. W. P. Evans, M.A., Dr. Cockayne, Mr. E. G. Hogg, M.A., Mr. A. E. Flower, M.A., B.Sc.

OTAGO INSTITUTE.

FIRST MEETING: *12th May, 1903.*

The President, Mr. A. Hamilton, delivered his presidential address dealing with the relation of the Government to various scientific projects, such as the erection of bench-marks around the coast, hydrographic surveys, magnetic surveys, marine biological station, sylviculture, &c., and especially with the proposed Maori Museum, concerning which he had issued a circular to the members of the House of Representatives detailing the functions and arrangement of such a museum. This valuable address was printed *in extenso* in the *Otago Daily Times*.

SECOND MEETING: *9th June, 1903.*

Mr. A. Hamilton, President, in the chair.

Professor Benham read a paper on "An Apparently New Species of *R. galecus (R. parkeri),*" and exhibited an excellent painted cast of the fish, executed by Mr. E. Jennings, the taxidermist of the Museum.

Professor Benham exhibited specimens of a new leech recently obtained at Open Bay Island during a biological excursion by Messrs. L. Cockayne and Dunlop; and a paper entitled "A New Species of Leech (*Hirudo antipodum*) recently discovered in New Zealand" was laid on the table.

Professor Park read a paper, "The Jurassic Age of the Maitai Formation," which was subjected to criticism by Dr. P. Marshall.

Dr. P. Marshall laid on the table a paper on "The Boulders in Triassic Conglomerate at Nelson," of which he gave an epitome.

Mr. C. S. S. Cooper read a paper on "A New Experiment in Light."

Professor Park urged the Council of the Institute to take steps to induce the Government to erect, at suitable places along the coast, bench-marks, in order that accurate information as to the secular movements by land and sea might be available for future observers.

The President promised that the Council should proceed in the matter.

THIRD MEETING: *14th July, 1903.*

Mr. A. Hamilton, President, in the chair.

Paper.—"Provençal Troubadours," by Professor T. G. R. Blunt.

FOURTH MEETING: *11th August, 1903.*

Mr. A. Hamilton, President, in the chair.

The President exhibited a specimen of *Sirex* found imbedded in some "moulding" imported from America, and made remarks on its life-history as illustrating the manner in which insects may be dispersed from one country to another.

Professor Benham exhibited a fine specimen of *Aturia ziczac* var. *australis*, recently presented to the Museum by Mr. A. Hamilton, who had obtained it at Wharekuri.

Amongst other exhibits were specimens of the above fossil in various conditions of fossilisation, which had been remounted to show their characteristics; also, a live lizard, apparently a new species of *Lygosoma*, the pouched form of *Geotria*, and other recent additions to the Museum.

Professor Benham gave a *résumé* of a paper on "The Oligochæta of the New Zealand Lakes," founded on the material collected by Mr. Keith Lucas during his recent biological survey.

Professor Park read a paper on "The Subdivisions of the New Zealand Trias," which was discussed by the President, Dr. Marshall, and Professor Benham.

FIFTH MEETING: *8th September, 1903.*

Mr. A. Hamilton, President, in the chair.

A paper on "The Sparrow Plague and its Remedy" was read by Mr. A. Bathgate, in which the author advocated the introduction of certain birds, such as shrikes, which in America prey upon sparrows.

A discussion ensued, in which members of the Otago Acclimatisation Society (by invitation) took part, as well as Messrs. G. M. Thomson, Gilkison, and Benham, all of whom strongly deprecated this method of meeting the annoyance.

SIXTH MEETING: *13th October, 1903.*

Mr. George M. Thomson, Vice-President, in the chair.

Mr. C. S. S. Cooper gave an interesting account of the recent researches by Rutherford, Curie, and others on "Radium and Radio-activity."

Papers.—1. "On the Physical Properties of Kauri-gum," by Mr. Cooper.

2. "A Supposed Heat Effect," by Mr. Cooper.

3. "On the Regeneration of Cyanide-solutions," by Mr. Doveton; communicated by Professor Park.

4. "Notes on a Small Collection of Fossils from Whare-kuri," by Mr. A. Hamilton.

5. "Notes on Old Native Settlements in various Parts of Murihiku," by Mr. A. Hamilton. (See "Handbook of the Australasian Association for the Advancement of Science," Dunedin, 1904.)

6. "On Abnormal Developments in New Zealand Ferns; with a List of Papers by various Authors on the Ferns of New Zealand," by Mr. A. Hamilton.

7. "List of Papers and Notices on Botanical Subjects in the Transactions of the New Zealand Institute and other Publications," by Mr. A. Hamilton.

8. "On the Discovery of a Permo-carboniferous Formation at Mount Mary, in North Otago," by Professor Park.

9. "On the Geology of the North Head at Waikouaiti," by Professor Park.

10. "Effect of Temperature on Gold-cyanide Solutions," by Mr. D. B. Waters.

ANNUAL MEETING: *3rd December, 1903.*

Mr. A. Hamilton, President, in the chair.

Papers.—1. "Notes on some Extinct Birds recently found near Ngapara," by Mr. A. Hamilton.

2. "Moriori Carving on the Trunks of Karaka-trees," by Mr. A. Hamilton.

3. "Second Supplement to Materials for a Bibliography of the *Dinornithidæ*," by Mr. A. Hamilton.

4. "The Sipunculids of New Zealand," by Professor Benham.

Annual Report.

Since the last report your Council has met nine times for the transaction of business.

During the year Mr. Justice Chapman and Mr. Chamberlain forwarded resignations as members of the Council, but, in view of the near approach of the annual general meeting, it was not considered necessary to fill their places on the committee. Your Council desires to place on record its high appreciation of the work of Mr. Justice Chapman, who has been a member of the Council for twenty years.

During the year five members of the Institute have resigned, and five new members have been elected. The total number of members is 112.

The present session has included seven general meetings. At one of these Professor T. G. R. Blunt, of Canterbury College, read a paper on "Provençal Troubadours," which was highly appreciated by a large attendance of members. A paper by Mr. A. Bathgate on "The Sparrow Plague" also excited general interest; and the Council wishes to record its sense of obligation to Mr. James Allen for consenting to deliver a lecture on "The Cook Islands" as a fitting close to the session.

The Council wishes to draw the attention of members to the forthcoming meeting of the Australasian Association for the Advancement of Science, to be held in Dunedin on the 10th January, 1904. It is hoped that all members of the Institute will co-operate in making the meeting as successful as possible.

Since the last annual meeting the resignation of Sir James Hector has necessitated a change in the legislation under which the New Zealand Institute and its affiliated local institutes were constituted. A Bill has lately passed through Parliament giving effect to various changes that were suggested by the Council of the Canterbury Philosophical Institute and approved by your Council and other bodies. The most important changes are—(1) More direct representation of the local institutes on the Board of Governors of the New Zealand Institute; (2) the appointment of the President of the New Zealand Institute and the Editor of the Transactions by the Board of Governors. In accordance with the provisions of this Bill your Council has appointed Messrs. G. M. Thomson and A. Hamilton as our representatives on the Board of Governors.

The important work, the "Index Faunæ Novæ-Zealandiæ," undertaken by Captain Hutton and the Philosophical Institute of Canterbury, is completed. A few advance copies have been received in Christchurch, and no doubt the work will be ready for distribution shortly.

In regard to the marine-fish hatchery, Mr. George M. Thomson, as the Institute's representative, reports that work has proceeded satisfactorily. A large concrete tank for supplying water to the hatching-house, &c., has been constructed, an enclosure has been made for two ponds for breeding fish, and a site cleared for the erection of the building which is to contain the hatching-house, aquarium-house, and laboratory. This building and a house for the caretaker are now in course of erection, and it is expected that they will be completed by the end of the year. Fittings for the laboratory and hatching-house have been ordered from Europe and America, and it is intended to open the station during the forthcoming meeting of the Australasian Association. Your Council has so far paid over £100 of the £250 promised to this undertaking.

A list of volumes added to the library was appended.

The balance-sheet, duly audited, was also adopted.

Abstract.

The receipts for the year, including a balance brought forward of £51 19s. 2s., amount to £103 19s.; the expenses were £79 18s. 2d.: leaving a balance of £34 11s. 11d. in the hands of the banker.

Election of Officers for 1904.—*President*—Dr. Benham; *Vice-Presidents*—Dr. T. M. Hocken and Mr. J. C. Thomson; *Council*—Messrs. A. Bathgate, Dr. Colquhoun, J. S. S. Cooper, Professor Park, G. M. Thomson, D. B. Waters, and R. Gilkison; *Secretary*—Dr. Marshall; *Treasurer*—Mr. W. Fels; *Auditor*—Mr. D. Brent.

Professor Benham congratulated Mr. Hamilton on his appointment to the Directorship of the Colonial Museum, and expressed his indebtedness to him for many kindnesses shown to him personally and to the Museum, as well as regret at the loss which the Institute would sustain on his departure to Wellington.

Mr. G. M. Thomson and Professor Park also spoke in appreciatory terms of Mr. Hamilton's services to the Institute as office-bearer and member of Council.

It had been arranged that Mr. James Allen, M.H.R., should give a lecture on "The Cook Islands," but owing to a mishap with the lantern the lecture had to be interrupted, and it was delivered to a large audience at a special meeting on the 8th December.

WESTLAND INSTITUTE.

Annual General Meeting.

The President, Mr. J. B. Lewis, in the chair.

Annual Report.

In presenting this report the Trustees of the Institute have every confidence that it will meet with the approval of its members, and although the past year has not been what may be termed a phenomenal one, still they are satisfied the Institute maintains a steady position, and that its influence and utility have a fixed and permanent foundation, requiring only better support from many of the citizens, which it richly deserves.

A matter of considerable importance in connection with the Institute has lately arisen, and is still pending—viz., that of obtaining from Mr. Carnegie a grant for the erection of a suitable building for a public library and museum.

A good deal of correspondence bearing on the subject has passed between His Worship the Mayor, the Institute, and the Borough Council, owing to the necessity of certain conditions imposed by Mr. Carnegie being complied with preparatory to that gentleman signifying his consent to the grant, and a conference has lately been held between the members of the Borough Council and the Trustees of the Institute in order to accomplish the object in view, with the result that there is every probability of pending difficulties being overcome.

However, assuming the application will be ultimately successful, such a building as that proposed will not only be a great acquisition to the town, but a decided boon to the public.

The members' roll now contains sixty-seven names; but it is to be regretted that the membership of so worthy an institution has not increased to a greater extent, seeing the many advantages to be obtained from it by the payment of a small subscription.

During the past year several committee meetings have been held and were well attended, unremitting attention having been given to all matters of interest in reference to the Institute, and during that period the library has been supplemented by the addition of many new works, fiction and otherwise.

The reading-room has been well supplied with the leading daily, local, and other newspapers, and the Trustees desire to record their thanks for the many donations of newspapers to the Institute from newspaper-proprietors.

The Museum, under the continued able management of the indefatigable curator, has had every care and attention bestowed upon it, and, as a place of resort, is even more popular than ever.

The ordinary subsidies from the Government, Borough Council, and Harbour Board have been of material assistance in augmenting the limited income of the Institute.

The Hon. Treasurer has, in his periodical statements, shown that the funds of the Institute are in a satisfactory condition, and the balance-sheet to be presented by him at this meeting will be found to contain the usual items necessary for properly working the Institute, the expenditure having been kept within reasonable limits.

Election of Officers for 1904.— *President*—Mr. J. R. McNaughton; *Vice-President*—Dr. Macandrew; *Treasurer*—Mr. Mabin; *Committee* — Messrs. Clarke, Dunne, Heinz, Mahan, Michel, Morton, Park, Beare, Lewis, Solomon, Corner and Dr. Teichelmann.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Annual Report.

During the past year seven meetings of the Institute were held, including the annual business meeting. At the ordinary meetings three lectures were delivered and six papers read. The Council met five times during the year. On the whole, the session may be considered a very successful one.

The change that has taken place in the government of the New Zealand Institute is worthy of note. By "The New Zealand Institute Act, 1903," branch institutes are now entitled to direct representation on the Board of Governors. Your Council, in December last, unanimously elected Mr. Hill as this branch's representative on the Board, and Mr. Hill attended the first meeting of the newly constituted Board in Wellington last month.

Considerable additions have been made to the library during the year, about forty volumes having been added. Unfortunately, the value of the Institute's library is not known to the general public, and the Council feel that if members would bring under the notice of their friends and others the large number of up-to-date scientific works that have been added in recent years there would be a considerable increase in membership.

The only additions to the Museum have been two *meres*, one *taiaha*, and one walking-stick, all deposited by Mr. McCulloch, of Ongaonga.

Three new members were elected during the year, and four old members resigned.

The balance-sheet shows a fair credit balance, but the expenditure for the year has been in excess of receipts.

List of Papers read during the Session 1903.

May 4.—The President, Dr. Leahy, delivered the inaugural address, his subject being "Meteorology in Relation to Public Health."

June 1.—Lecture by Dr. Kennedy, "The Moon as seen through the Telescope," illustrated by numerous lantern-slides.

July 6.—Lecture by Mr. G. Hogben, "A Chat about Earthquakes," illustrated by a large number of lantern-slides.

August 3.—Papers: Taylor White, "On a Viviparous Lizard; F. Hutchinson, jun., "Our Shingle and its Origin"; W. Dinwiddie, "The Study of Character."

September 7.—Lecture by Dr. Reid Mackay, "The America Cup, and International Yacht-racing," illustrated by 120 slides.

September 21.—Paper by H. Hill, "Taupo, Past and Present—a Geological Review," illustrated by lantern-slides.

NELSON INSTITUTE.

Election of Officers for 1904.—*President*—D. Grant; *Vice-President*—F. G. Gibbs; *Hon. Secretary and Treasurer*—A. J. Redgrave; *Librarian*—B. Reeves.

APPENDIX

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

FINSCH, OTTO, Ph.D., of Bremen, Leiden, Holland.

HOOKER, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., Royal Gardens, Kew.

1873.

CAMBRIDGE, The Rev. O. PICKARD, M.A., C.M.Z.S., Bloxworth Vicarage, Wareham, Dorsetshire.

GÜNTHER, A., M.D., M.A., Ph.D., F.R.S., Litchfield Road, Kew Gardens, Surrey.

1874.

MCLACHLAN, ROBERT, F.L.S., 23, Clarendon Road, Lewisham, S.E.

NEWTON, ALFRED, F.R.S., Magdalen College, Cambridge, England.

1875.

SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., Zoological Society, London.

1876.

BERGGREN, Dr. S., Lund, Sweden.

1877.

SHARP, Dr. D., University Museum, Cambridge.

1883.

Lord KELVIN, P.C., G.C.V.O., D.C.L., F.R.S., 13, Eaton Place, S.W.

ELLERY, ROBERT L. J., F.R.S., Observatory, Melbourne.

1885.

SHARP, RICHARD BOWDLER, M.A., F.L.S., Zoological Museum, Cambridge.

WALLACE, A. R., F.L.S., Broadstone, Wimborne, England.

1890.

NORDSTEDT, Professor OTTO, Ph.D., University of Lund, Sweden.

LIVERSIDGE, Professor A., M.A., F.R.S., Sydney.

1891.

GOODALE, Professor G. L., M.D., LL.D., Harvard University, Massachusetts, U.S.A.

1894.

DYER, Sir W. T. THISELTON-, K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Royal Gardens, Kew.

CODRINGTON, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

1895.

MITTEN, WILLIAM, F.L.S., care of Linnean Society, London.

1896.

LYDEKKER, RICHARD, B.A., F.R.S., British Museum, South Kensington.
LANGLEY, S. P., Smithsonian Institution, Washington, D.C.

1900.

AGARDH, Dr. J. G., University of Lund, Sweden.
AVEBURY, Lord, P.C., F.R.S., High Elms, Farnborough, Kent.
MASSEE, GEORGE, F.L.S., F.R.M.S.

1901.

EVE, H. W., M.A., 37, Gordon Square, London.
HOWES, G. B., LL.D., F.R.S., Royal College of Science, South Kensington.
GOEBEL, Dr. CARL, University of Munich.

1902.

Professor G. O. SARS, University of Christiania, Norway.

1903.

Professor OTTO J. KLOTZ, 437, Albert Street, Ottawa, Canada.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

[* Life members.]

Adams, C. E.
Adams, C. W., Blenheim
Adams, Dr.
Allen, F.
Aston, B. C.
Atkinson, A. R.
Barker, G. H.
Barnes, R. J.
Barraud, W. F.
Barton, W.
Bates, Rev. D. C.
Beetham, G.
Beetham, W. H.
Bell, E. D.
Bell, H. D.
Best, E., Hadfield
Blair, J. R.
Bothamley, A. T.
Brandon, A. de B.
Brown, E. G., A.I.C.E.
Browne, M. H.
Buick, T. L., Palmerston N.
Buller, Sir W. L., K.C.M.G., D.Sc., F.R.S.
Caldwell, R.
Campbell, J. P.
Chalmers, W. M.
Chapman, Martin
Chapple, Dr.
Chudleigh, E. R.
Cockayne, A.
Cohen, W. P.
Connal, E.
Cowper, D. A. S.
Davy, Dr. T. G., Kumara
Dawson, B.
Denton, George
Easterfield, Prof., M.A., Ph.D.
Elliot, Major E. H. J.
Evans, W. P., M.A., Ph.D.
Ewen, C. A.
Farquhar, H.
Ferard, B. A., Napier
Ferguson, W., C.E.
Field, H. C., Wanganui
Fitzgerald, G.
Fletcher, Rev. H. J., Taupo
Fraser, Hon. F. H.

Freeman, H. J.
Freyberg, C.
Fyffe, Dr. K.
Gifford, A. C.
Gilruth, J. A.
Gordon, H., F.G.S.
Gore, A. H.
Gray, W., Palmerston N.
Hadfield, E. F.
Hanify, H. P.
Harcourt, J. B.
Harding, R. Coupland
Hastie, Miss J. A.*
Hector, Sir James, K.C.M.G., M.D., F.R.S.
Herbert, W. H.
Hislop, Hon. T.
Hogben, G., M.A.
Holmes, R. L., F.R. Met. Soc., Fiji*
Holmes, R. T., Masterton
Hosking, Dr. A., Masterton
Hudson, G. V., F.E.S.
Hustwick, T. H.
Inwood, D., Canterbury
Jenkins, Digby A.
Johnson, G. Randall*
Joynt, J. W., M.A.
Keys, B.
King, T.
Kingsley, R. I., Nelson
Kirk, Professor H. B., M.A.
Kirk, T. W., F.L.S.
Krull, F. A., Wanganui
Lambert, T. S.
Lee, H. M.
Lewis, J.
Lewis, J. H., Otago
Liffiton, E. N., Wanganui
Litchfield, A. J., Blenheim
Lomax, H. A., Wanganui
Longton, Mrs. C. V.
Mackenzie, F. Wallace, M.B.
Maclaurin, Prof. R. C., M.A.
Mason, G. M.
Matheson, D.
Maxwell, J. P., M.Inst.C.E.
McDougall, A.
McKay, Alexander, F.G.S.
McLeod, H. N.
McWilliam, Rev. J., Otaki
Mestayer, R. L., M.Inst.C.E.
Moore, G.
Moorehouse, W. H. S.
Morison, C. B.
Murdoch, R., Wanganui
Nairn, C. J., Hawke's Bay
Newman, Alfred K., M.B., M.R.C.P.
Orr, Robert
Park, R. G.*
Pearce, A. E.
Petherick, E. W.
Pharazyn, C., Wairarapa
Phillips, Coleman
Pierard, C. H.
Pollen, Hugh
Powles, C. P.
Poynton, J. W.
Prendergast, Sir J.
Pringle, T.
Purdy, Dr. J. S.
Quail, A., Palmerston N.
Reid, W. S.
Richardson, C. T.
Richardson, Hon. G. F.
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Rowse, Rev. W., Greytown
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Rutherfurd, W. G.
Rutland, Joshua, Marlborough
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Simcox, W. H., Otaki
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Skerman, Dr. Sydney, Marton
Smith, Charles, Wanganui
Smith, M. C.
Smith, S. Percy, F.R.G.S.
Stewart, J. T., Wanganui
Stowell, H. M.
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Talbot, Dr. A. G.
Tanner, Cyril
Travers, H.

Tregear, E.
Turnbull, A. H.
Turnbull, R. T.
Turnbull, Thomas
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Wallace, James
Waterhouse, G. M., F.R.G.S.
Welch, W., Palmerston N.
Weyergang, C. H., Taranaki
Wilton, G. W.
Woodhouse, Alfred James, London
Young, J.

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Armitage, F. C., Ellerslie
Aubin, E. D., M.B., Thames
Bagnall, L. J., Auckland
Bakewell, R. H., M.D., Auckland
Ball, W. T., Auckland
Bankart, A. S. „
Bartley, E., Devonport
Bates, T. L., Newcastle, N.S.W.*
Batger, J., Auckland
Beere, D. M., C.E., Auckland
Best, Elsdon, Te Whaiti
Brett, H., Auckland
Broun, Captain T., F.E.S., Drury
Brown, Prof. F. D., Auckland
Brown, J., Epsom
Buchanan, J., Auckland
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Burton, Colonel, Lake Takapuna*
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Cameron, R. „
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Campbell, Sir J. L., M.D., Auckland*
Carey, M. F., Auckland
Carnie, A. R. „
Carr, R. A. „
Casey, M. „
Cheal, P. E. „
Cheeseman, H. H., M.R.C.S., Coromandel
Cheeseman, T. F., F.L.S., Auckland
Ching, T., Remuera
Clark, H. C., Auckland
Clark, M. A. „
Clarke, E. „
Cochrane, W. S. „
Combes, F. H. „
Cooper, C. „
Cooper, T. „
Cozens, G. „
Craig, J. J. „
Crosher, W. „
Cummings, H. „
Dannefærd, S. „
Darby, P. „
Duthie, D. W. „
Edson, J., Devonport
Egerton, Professor C. W., Auckland
Ewington, F. G., Auckland
Farmer, J., London
Fowlds, G., M.H.R., Auckland*
Fox, C. H., Norfolk Island
George, G. Auckland
Gilbert, T., Parnell
Girdler, Dr., Auckland
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Goldie, W. H., M.D., Auckland
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Gorrie, W. „
Gray, S. „
Haines, C. H., M.D., F.R.G.S., Auckland

Haines, H., F.R.C.S., Auckland
Hamer, J. H., C. E., Auckland
Hardie, J., Auckland
Harding, S., C.E., Auckland
Haszard, H. D. M., Thames
Henry, W., Auckland
Henton, J. S., Auckland
Herbert, T., Parnell
Howden, J., Auckland
Howell, J. H., B.Sc., Auckland
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Jones, H. W., Papakura
Kenderdine, J., Auckland
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Nicholson, O. R. „
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Tinne, H., London*
Tucker, W. F., Ellerslie
Upton, J. H., Auckland

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Vaile, E. E., Auckland
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Waterworth, A., Auckland
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Webster, Rev. W., Waiuku
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Williams, T. O., L.R.C.P., Auckland
Williams, Right Rev. W. L., Bishop of Waiapu, Napier
Wilson, A. P., Auckland
Winter, N. A., Onehunga
Withy, E., Opotiki*
Wrigg, A. A., C.E., Auckland
Yates, E., Auckland
Young, J. L., Auckland

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Anderson, Gilbert
Anderson, Mrs. A.
Bealey, S.
Beckett, T. W. Naylor
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Birks, L., B.Sc., Assoc.M. Inst.C.E.
Bishop, R. C.
Bishop, F. C. C.
Blunt, Prof. T. G. R., M.A.
Booth, G. T.
Bowen, Hon. C. C., M.A., F.R.G.S.
Bridges, G. G.
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Chilton, Professor C., D.Sc., M.A., M.B.*
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Cook, Professor C., M.A.
Craddock, A. R., B.Sc.
Cuthbert, E., M.Inst.C.E.
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Denniston, Mr. Justice
Dohrmann, Mrs.
Drummond, J.
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Evans, Prof. W. P., M.A., Ph.D.
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Finch, Dr.
Flower, A. E., M.A., B.Sc.
Frengley, Dr.
Gray, Alex., B.A.
Gray, George, F.C.S.
Grimes, Right Rev. Bishop
Hall, Sir John, K.C.M.G.
Harling, C.
Haselden, W. R.
Hilgendorf, F. W., M.A., B.Sc.
Hogg, E. G., M.A.
Hutton, Capt. F. W., F.R.S., President New Zealand Institute*
Kaye, A.
Kirkaldy, G. W.
Kitchingman, Miss E.
Laing, R. M., M.A., B.Sc.
Lee, H. M.
Lowrie, Prof. W., M.A., B.Sc.
Marriner, G. R.
Mayne, J. B.
Mollett, T. A.*
Moyes, W. H., B.A.
Murray-Aynsley, H. P.
Nairne, R.

Olliver, Miss A. M., M.A., B.Sc.
Page, S.
Pairman, Dr. W. T.
Palmer, Joseph
Prideaux, E. B. R., M.A., B.Sc.
Purnell, C. W.
Pycroft, A. T.
Reece, W.
Rhodes, R. Heaton, M.A.
Roper, E. W.
Scott, Professor R. J., M.Inst. Mec.E.
Scott, Henry
Scott, W. L., M.A.
Seager, J. H.
Sims, A.
Smith, W. W., F.E.S.
Sparkes, W.
Speight, R., M.A., B.Sc.
Stevenson, Miss E., M.A.
Symes, Dr. W. H.*
Thomas, Dr. W.*
Thomas, R. D.
Trolove, P.
Waelick, M. G.
Wall, Prof. A., M.A.
Waymouth, F.
Williams, C. J., M.Inst.C.E.

OTAGO INSTITUTE.

[* Life members.]

Allan, Dr. W.
Allen, J., M.H.R., M.A.
Armstrong, F.
Barnett, L. E., M.B., F.R.C.S.
Barningham, J.
Batchelor, F. C., M.D., M.R.C.S.
Bathgate, Alexander*
Bell, A. D.
Benham, Professor, D.Sc., M.A., F.Z.S.
Beverley, Arthur
Bews, D. J.
Black, A. D.*
Black, Professor, D.Sc.
Blair, John
Brent, Daniel, M.A.*
Brown, Thomas
Brown, William
Brown, William, M.B., C.M.
Buchanan, N. L.*
Burnside, J. A.
Campbell, Robert
Carew, W. S.
Chamberlain, C. W.
Chapman, C. R.
Chapman, Mr. Justice
Chisholm, Robert
Collier, E. E.
Collins, F. J.
Colquhoun, D., M.D., M.R.C.S.
Cooper, J. S. S., M.A., B.Sc.
Don, Dr. J. R., D.Sc., M.A.
Duncan, Peter
Fairbairn, Thomas B.
Fels, Willi
Fenwick, George
Ferguson, H. Lindo, M.D., F.R.C.S.I.
Fitchett, Dr. Frank
Fitzgerald, W. S.
Fulton, R., M.B., C.M.
Fulton, S. W.*
Gibb, Rev. J., M.A.
Gibbons, Professor, M.A.
Gilkison, Robert
Goyen, P.
Hamilton, Augustus
Hardy, H. F.
Hay, Dr. F.
Herbert, E.
Hocken, Dr. T. M., M.R.C.S., F.L.S.
Hosking, J. H.
Howes, G. W., F.E.S.
Jackson, Howard
Joachim, George *
Kempthorne, T. W.

King, Dr. F. Truby
Lamb, Thompson
Langmuir, John
Lillie, C. O., M.A.
Lusk, T. W.
Marchant, Miss M. E. A., M.A.
Marshall, Dr. P., D.Sc., M.A., F.G.S.
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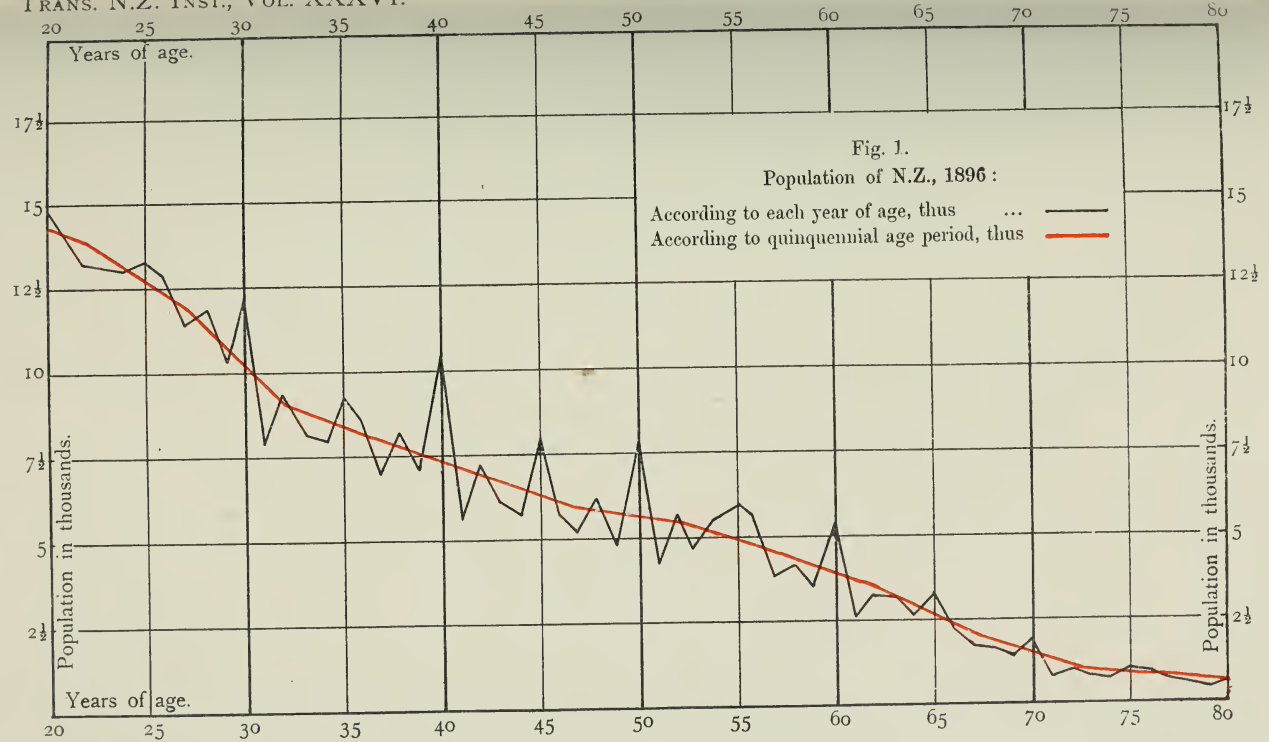

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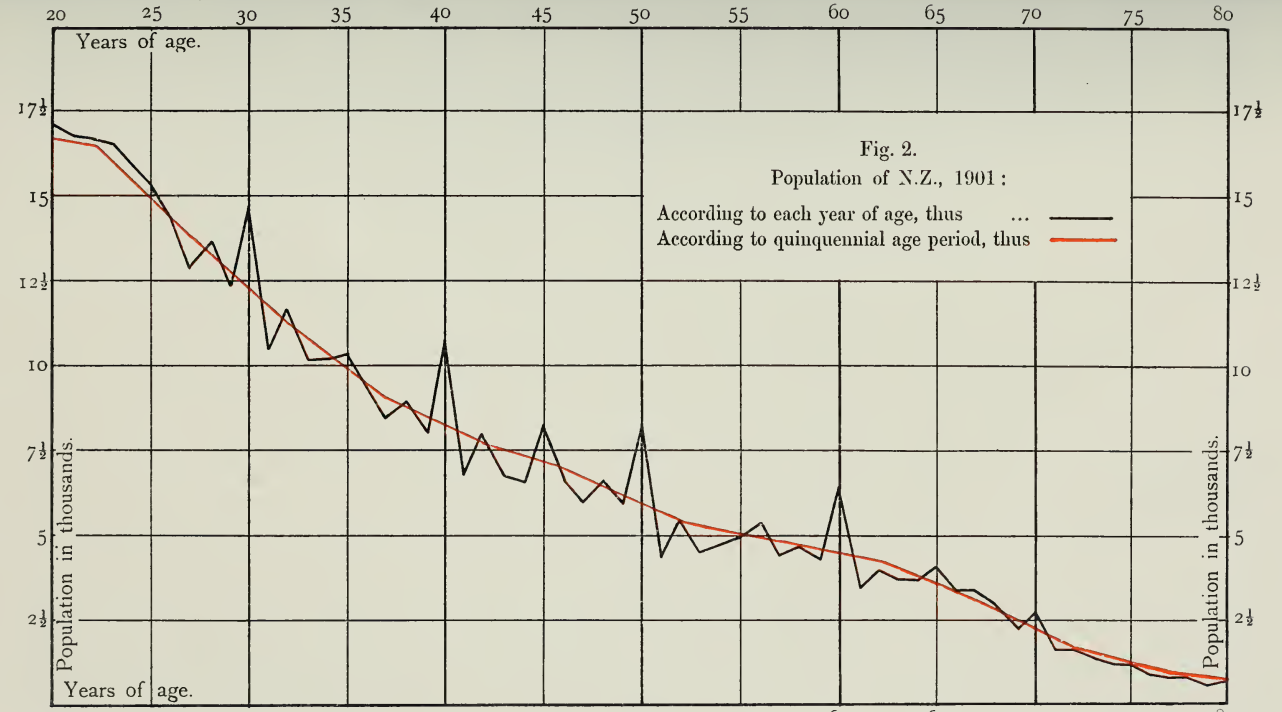

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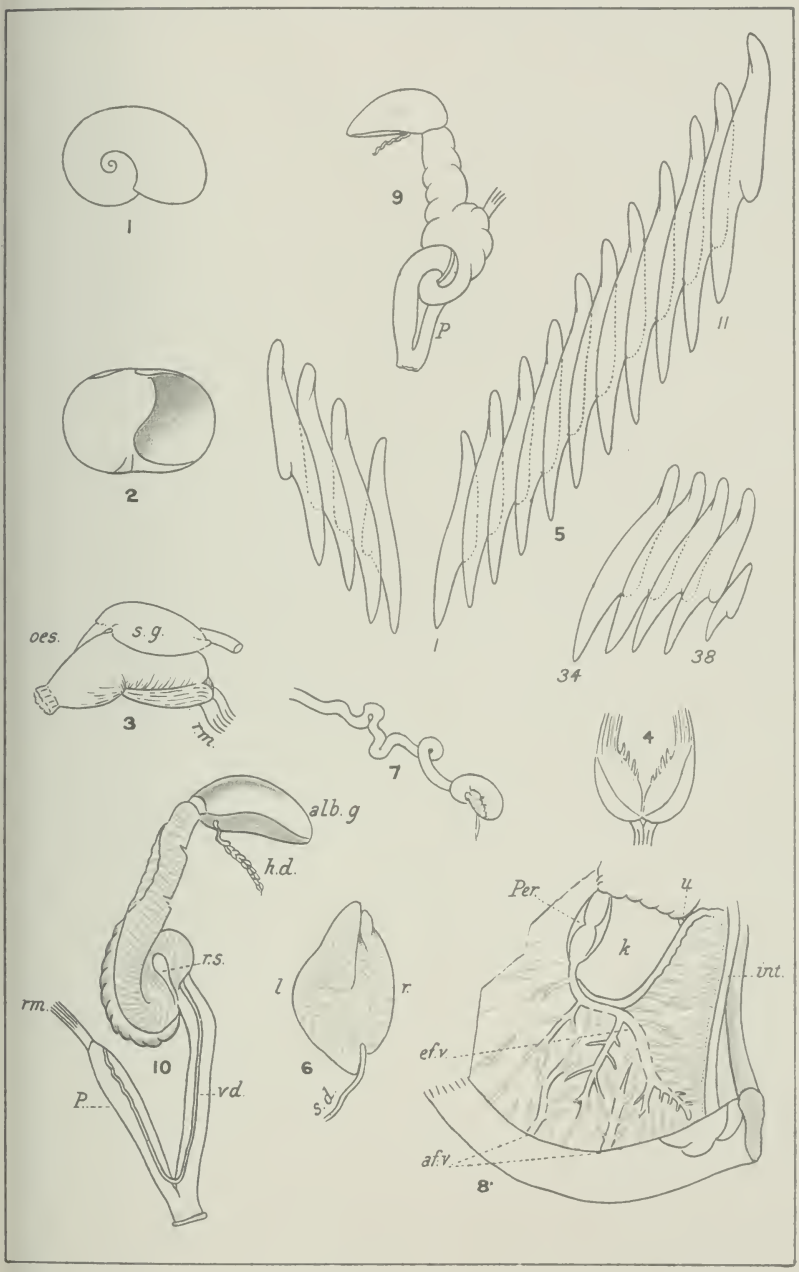

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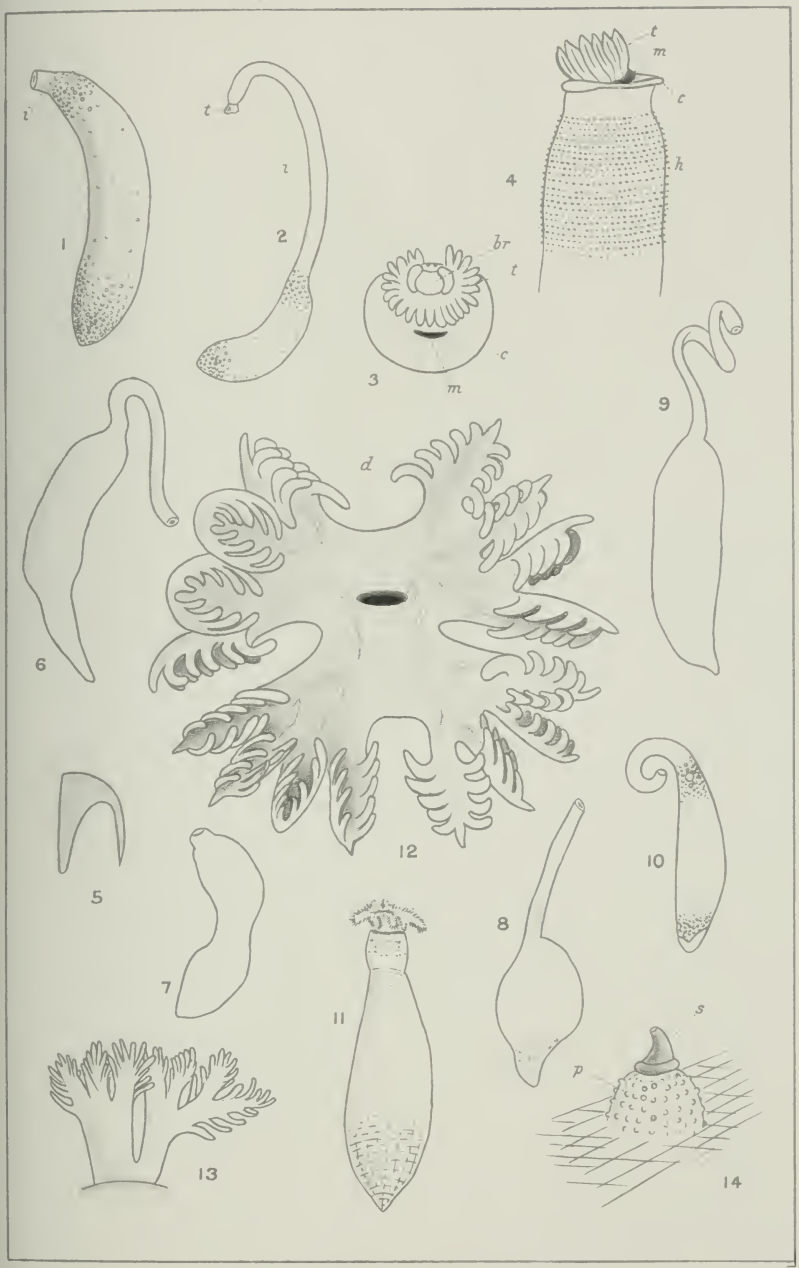

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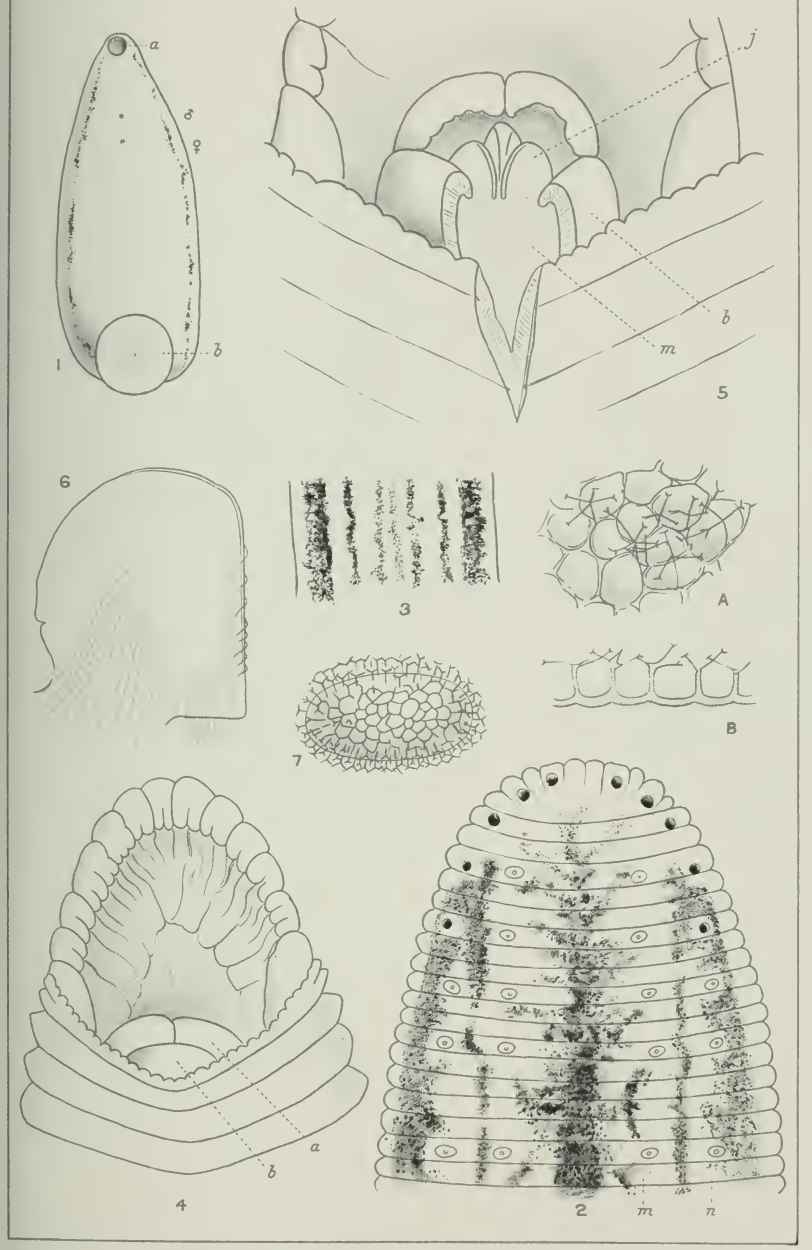

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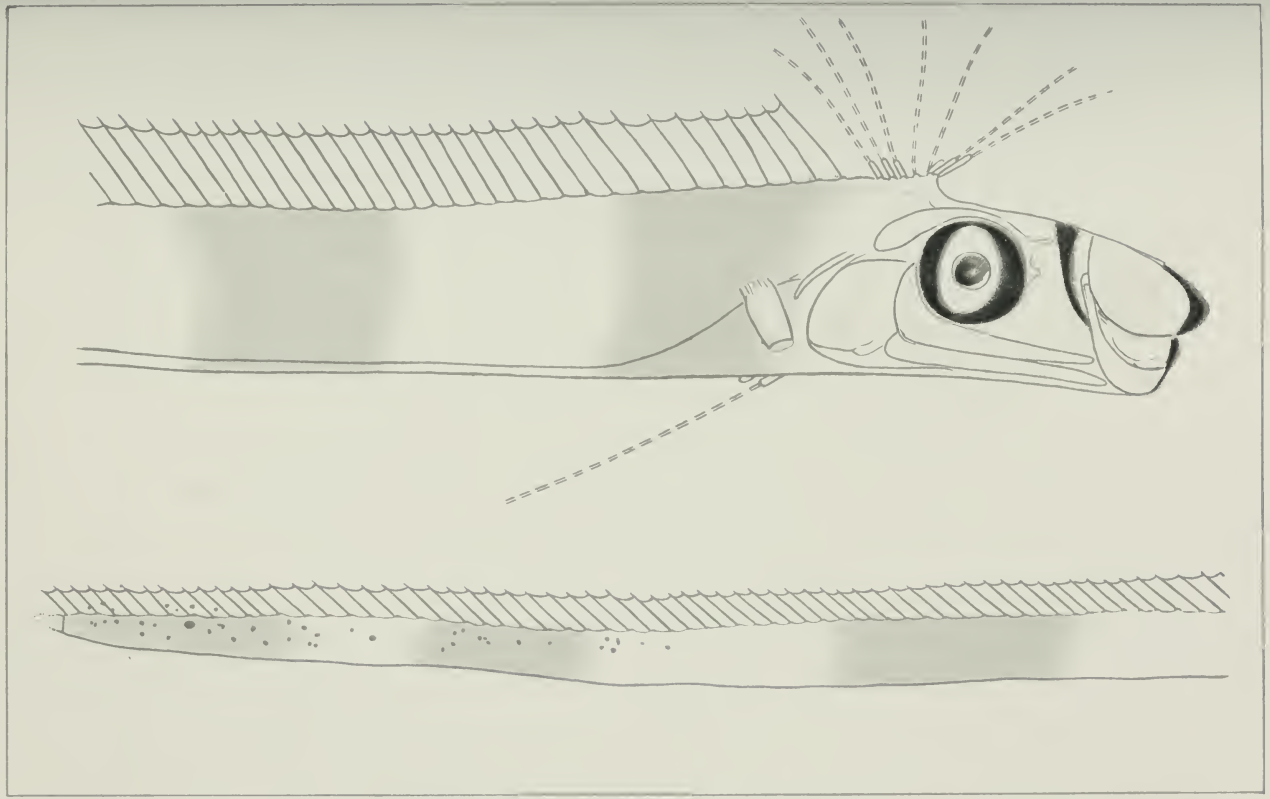

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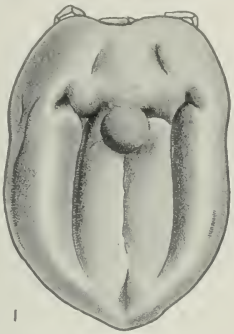
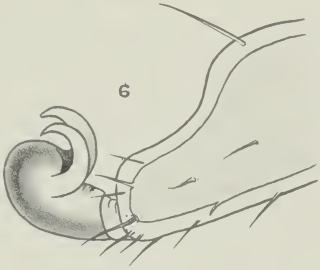
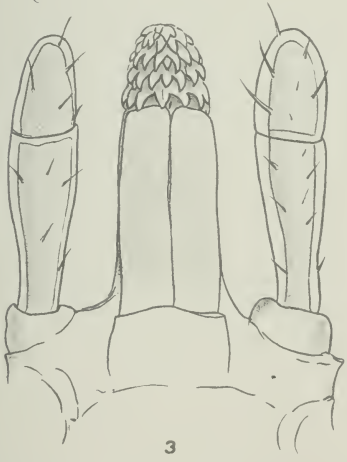
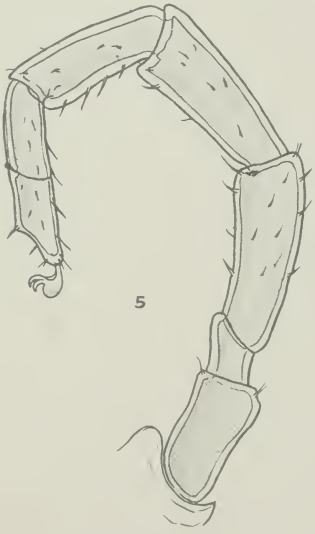


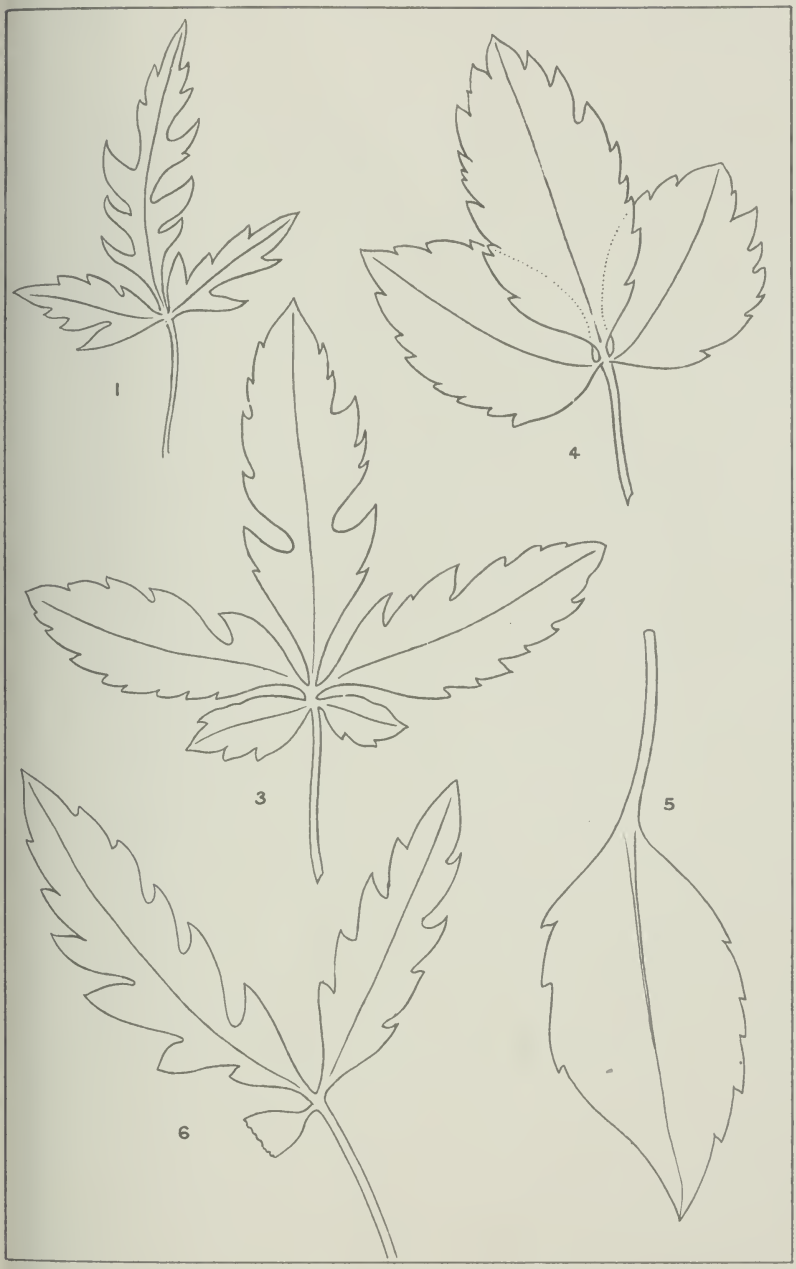






E.G.F. & C.C. del.

IXODES ANATIS.—Chilton.



LEAVES OF PANAX SIMPLEX.—Cockayne.

SAND DUNES, ENDERBY ISLAND.—Cockayne.

RATA FOREST, AUCKLAND ISLANDS.—Cockayne.

OLEARIA LYALLII FOREST, EWING ISLAND.—Cockayne.

OLEARIA LYALLII FOREST.—Cockayne.

EXTERIOR VIEW OF RATA FOREST, ENDERBY ISLAND.—Cockayne.

NORTH END OF AUCKLAND ISLAND FROM ENDERBY ISLAND.—Cockayne.

ARISTOTELIA FRUTICOSA.—Cockayne.

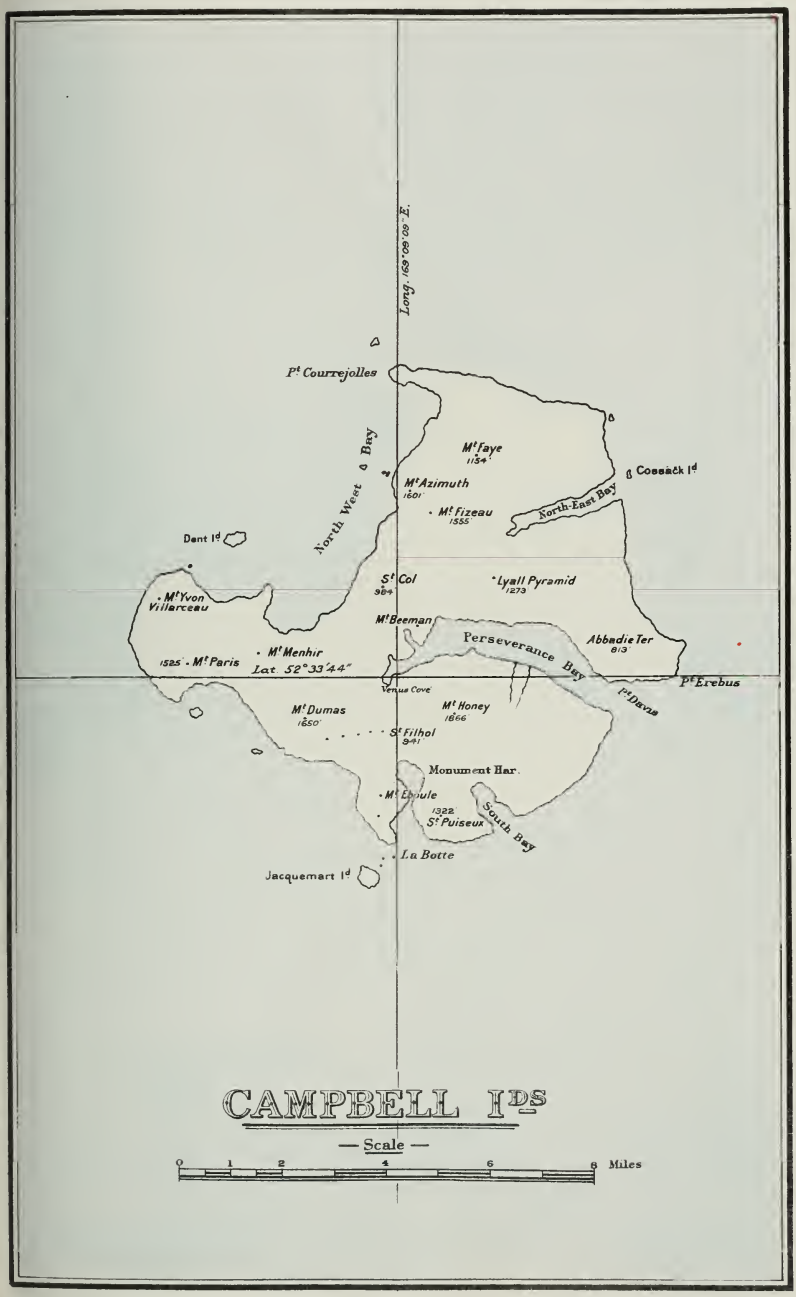
CLIFFS, ANTIPODES ISLAND.—Cockayne.

FLAT MEADOW, ANTIPODES ISLAND.—Cockayne.

ARALIA LYALLII, RUAPUKE ISLAND.—Cockayne.

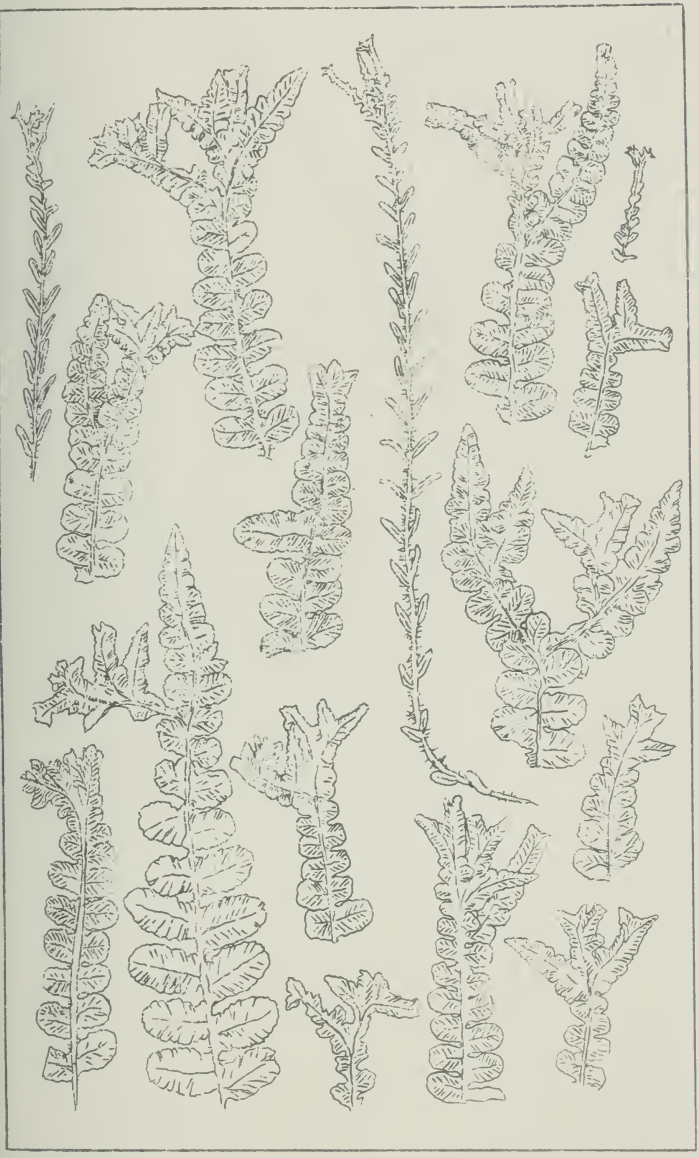
EFFECT OF MOIST AIR AND LIGHT ON VERONICA LYCOPODIOIDES.—Cockayne.

To illustrate paper by L. Cockayne.



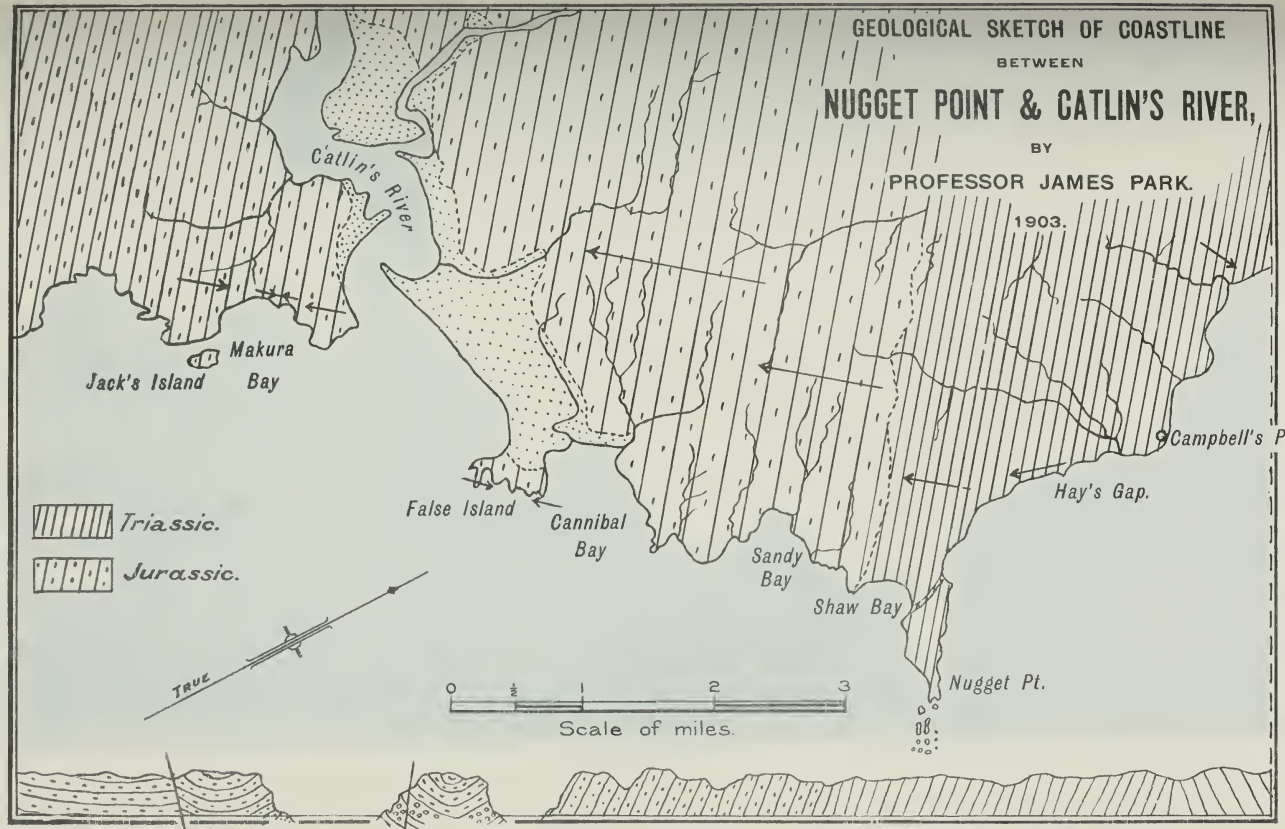
To illustrate paper by L. Cockayne.

ABNORMAL GROWTH OF PHORMIUM.—Williams.

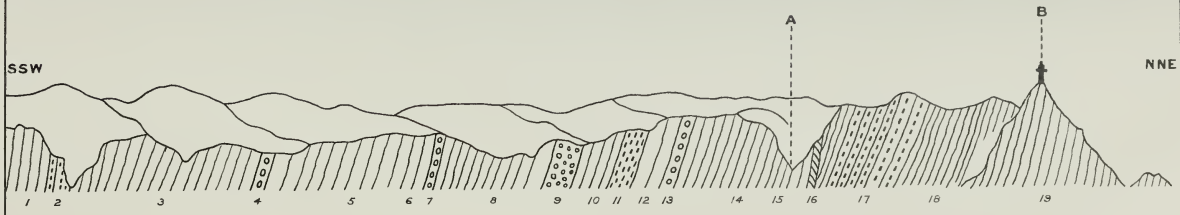


FERN VARIATIONS.—Hamilton.

FERN VARIATIONS.—Hamilton.



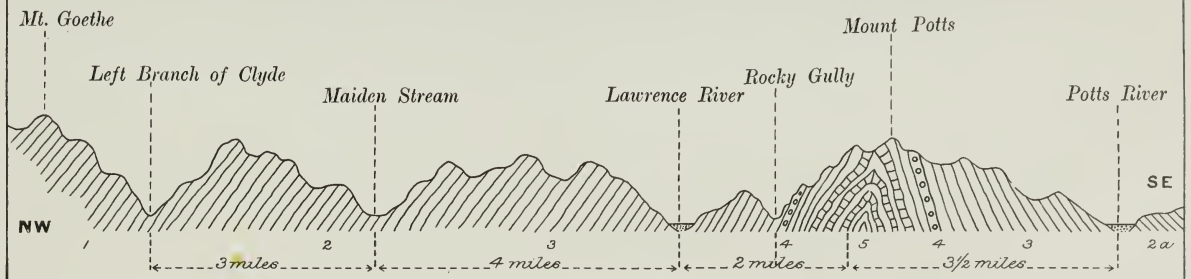
To illustrate paper by James Park.



SECTION, SOUTH HEAD, SHAW BAY TO NUGGET POINT.

1. Claystones and sandstones.
2. Athyris sandstone (pebbly).
3. Coarse sandstones.
4. Mytilus and oyster-bed (29 ft.).
5. Banded claystones and sandstones.
6. Trigonia-beds.
7. Granite conglomerate (10 in.).
8. Sandstones, with beds of claystone.
9. Breccia conglomerate.
10. Claystones and sandstones.
11. Greywacke.
12. Indurated claystones.
13. Breccia conglomerate.
14. Claystones and sandstones.
15. Halobia claystones.
16. Dyke of porphyrite.
17. Greywacke and sandstone.
18. Black (spiriferina) claystones.
19. Claystones, plant-beds.

A. Track to Roaring Bay. B. Nugget Point Lighthouse.

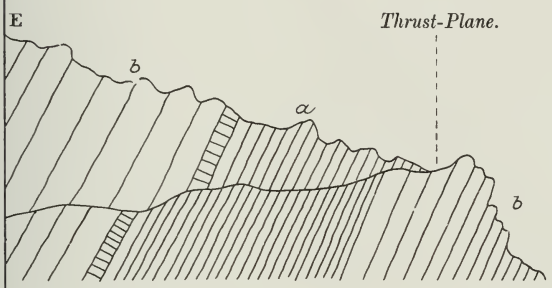


SECTION FROM MOUNT COOK RANGE TO POTTS RIVER.

Jurassic
1. Sandstones, with beds of claystone.
2. Sandstones, greywacke, and slaty claystone.
3. Sandstones and slaty shales.

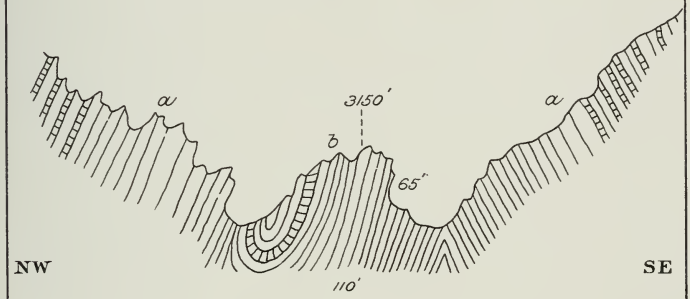
Triassic
4. Fossiliferous claystones and conglomerate.
5. Tank Gully plant-beds. 2A. Inoceramus, Pentacrinus.

SUBDIVISION OF LOWER MESOZOIC.—Park.



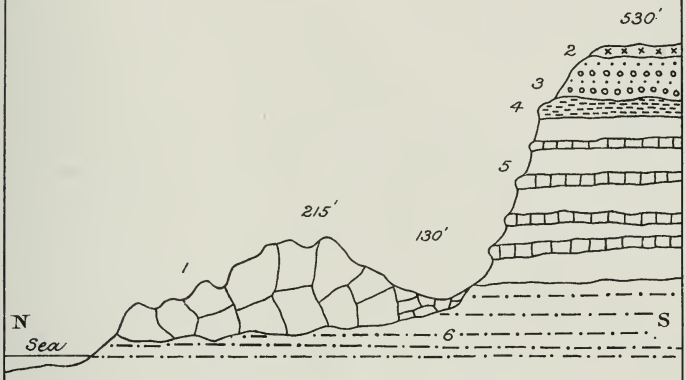
SOUTH SIDE OF TANK GULLY, MOUNT POTTS.

a. Thin-bedded shales and sandstones.
b. Grey sandstones.

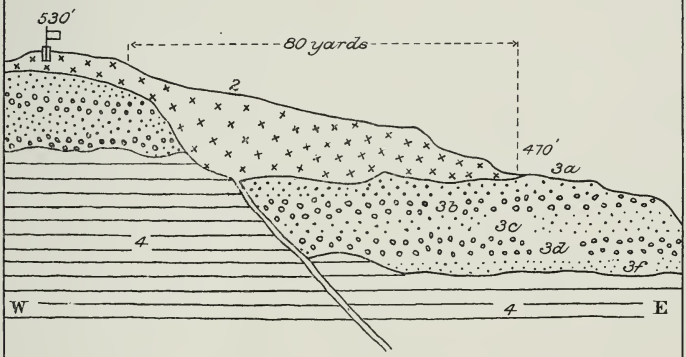


SECTION ACROSS TANK GULLY.

a. Sandstones.
b. Black carbonaceous shales with fossil fern-leaves.



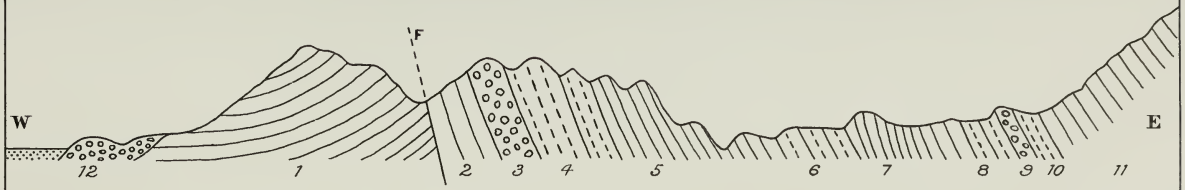
SECTION, WAIKOUAITI NORTH HEAD.



SUMMIT OF MOUNT CRONIN, WAIKOUAITI NORTH HEAD.

1. Talus deposit. 2. Basalt flow. 3. Gravel-bed. 3a. Grey silts. 3b. Coarse grits. 3c. Silts and Sands. 3d. Coarse gravels. 3f. Sands. 4. Grey sandstone. 5. Calcareous sandstone. 6. Blue clays.

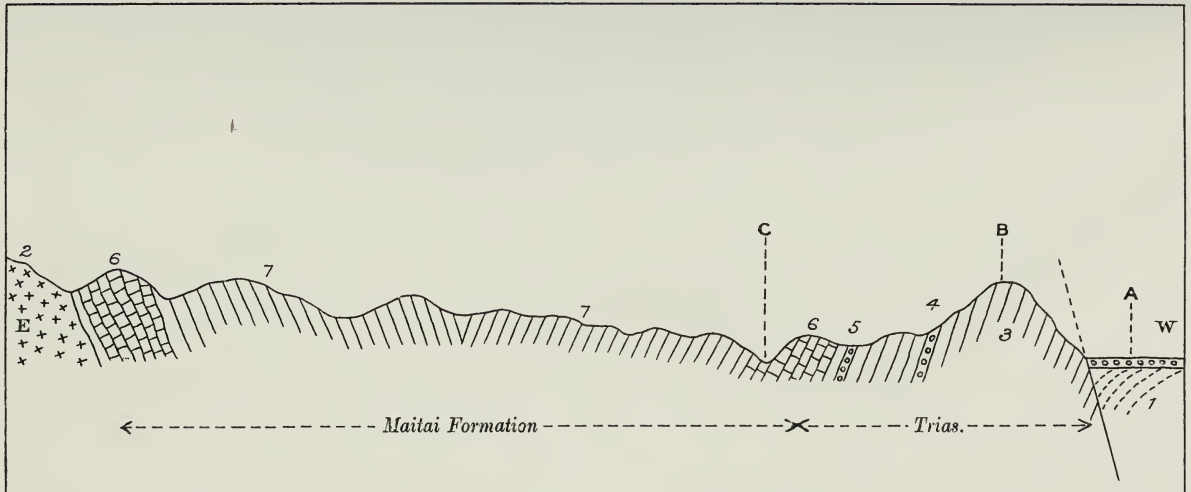
GEOLOGY OF WAIKOUAITI NORTH HEAD.—Park.



SECTION ALONG WELLS' CREEK, 88 VALLEY.

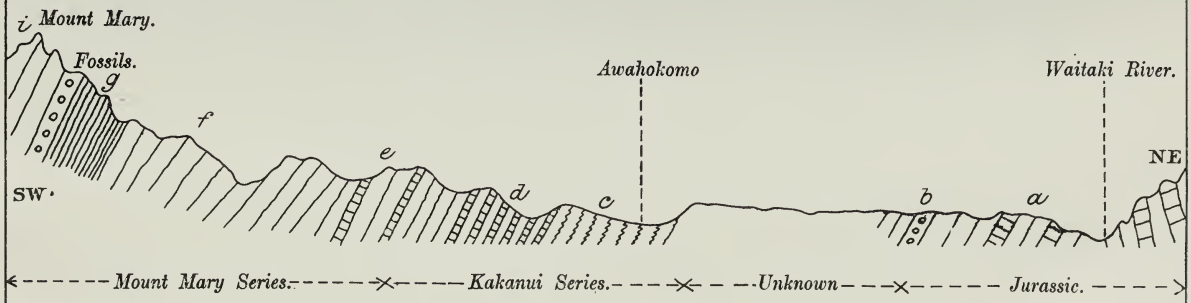
1. Halobia and spiriferina beds.
2. Claystones.
3. Lower granite conglomerate.
4. Gritty sandstone with spirifera, &c.
5. Mytilus claystones.
6. Claystones and sandstones.
7. Claystones with mytilus.
8. Pentacrinus and corals.
9. Upper granite conglomerate.
10. Athyris sandstone (pebbly).
11. Maitai sandstones, &c.
12. Pliocene gravels.

F. Thrust-plane.



A. Waimea Plain.
B. Mount Heslington.
C. Wairoa Gorge.
1. Lower tertiaries.
2. Serpentine.
3. Halobia and spiriferina beds.
4. Lower conglomerate.
5. Upper conglomerate.
6. Maitai limestone.
7. Maitai shales and sandstones.

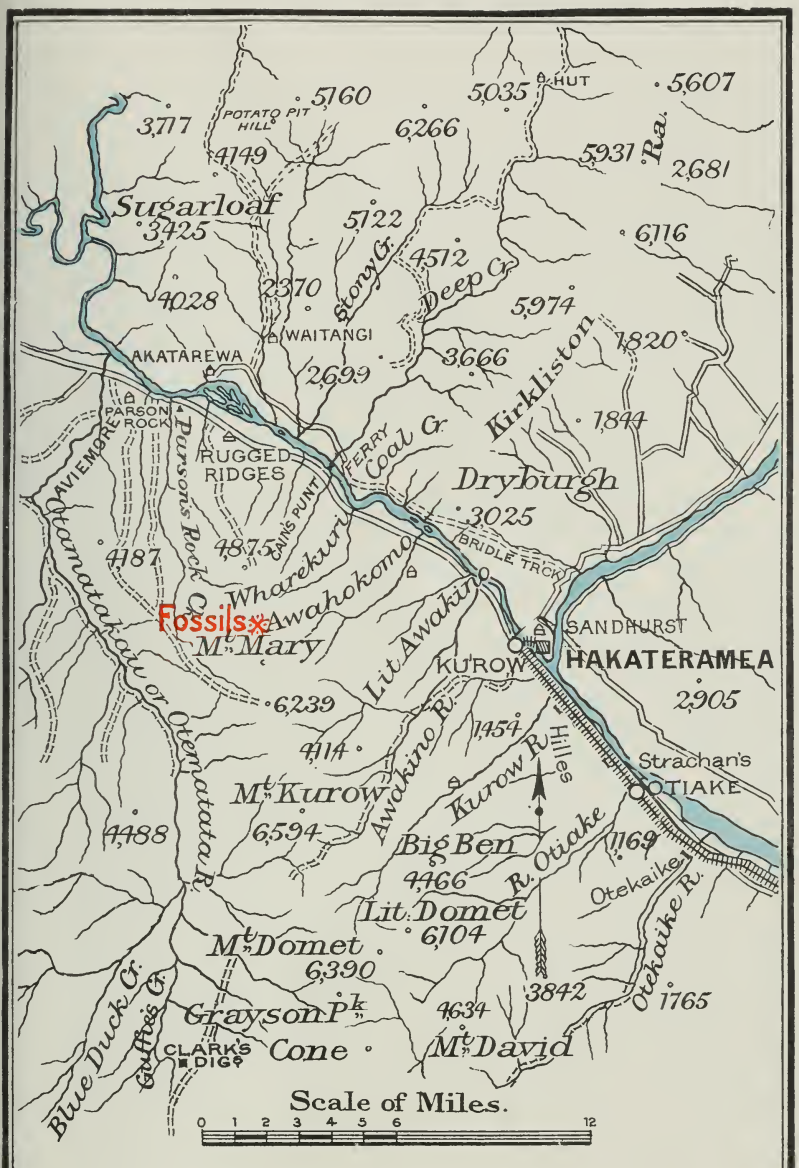
JURASSIC AGE OF MAITAI FORMATION.—Park.



SECTION FROM WAITAKI TO MOUNT MARY.

a. Claystones and sandstones.
b. Sandstone conglomerate.
c. Phyllites.
d. Banded phyllite and quartzite.
e. Sandstones, &c., altered.
f. Grey sandstones, gritstones, &c.
g. Slates and flaggy claystones.
i. Grey sandstones, &c.

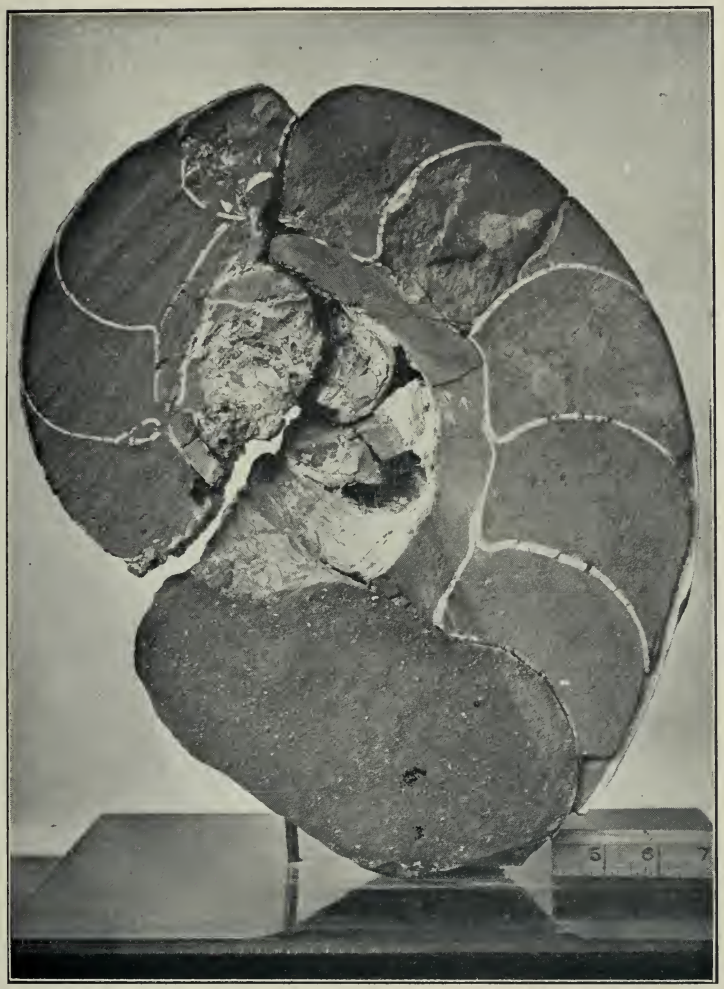
PERMO-CARBONIFEROUS ROCKS.—Park.



PLAN OF PART OF WAITAKI VALLEY.

To illustrate paper by James Park.

ATURIA ZICZAC *var.* AUSTRALIS.—Hamilton.

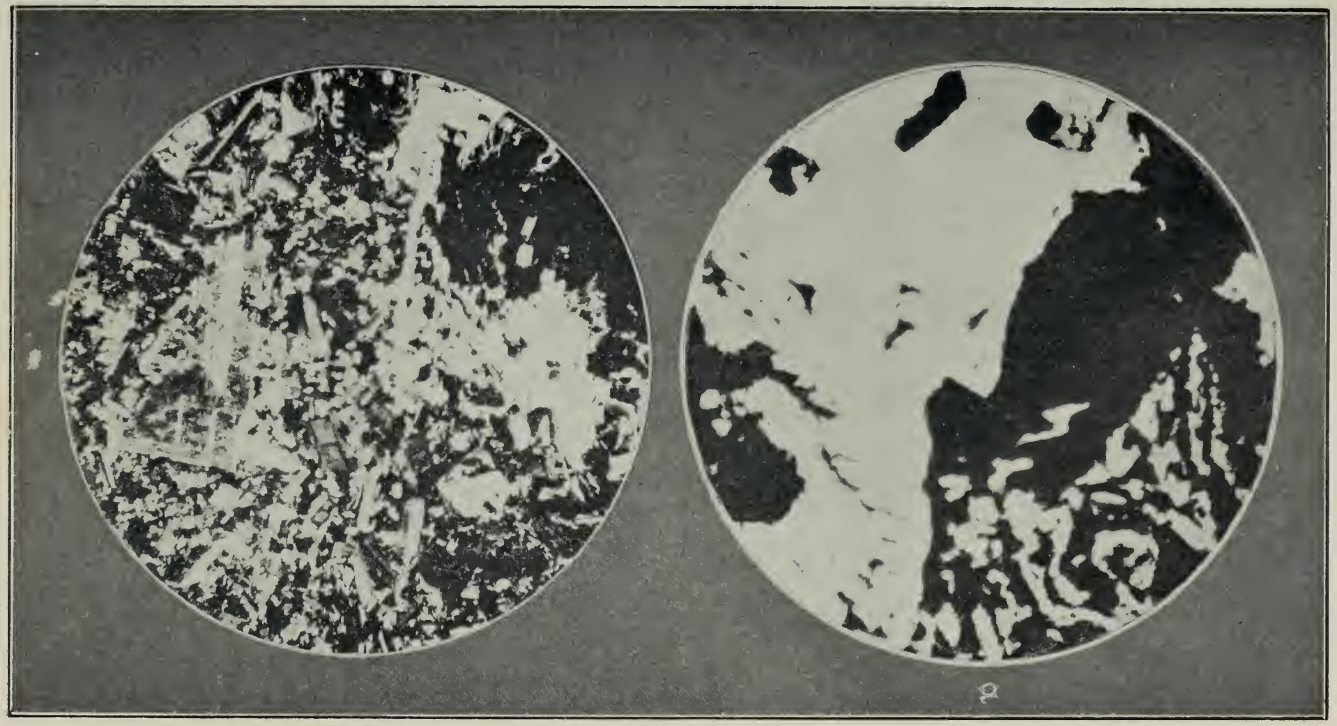


SECTION OF ATURIA ZICZAC *var.* AUSTRALIS.—Hamilton.

PLATE XXXIX.

a. Granite showing graphic intergrowth of orthoclase and quartz. Orthoclase in position of extinction. (C 278.)

b. Uralite porphyrite, crossed nicols. Crystal in the upper portion is a twinned augite partly uralitised. The larger crystals of plagioclase are imbedded in a groundmass of smaller crystals of plagioclase, fibrous hornblende, and magnetite. (C 284.)



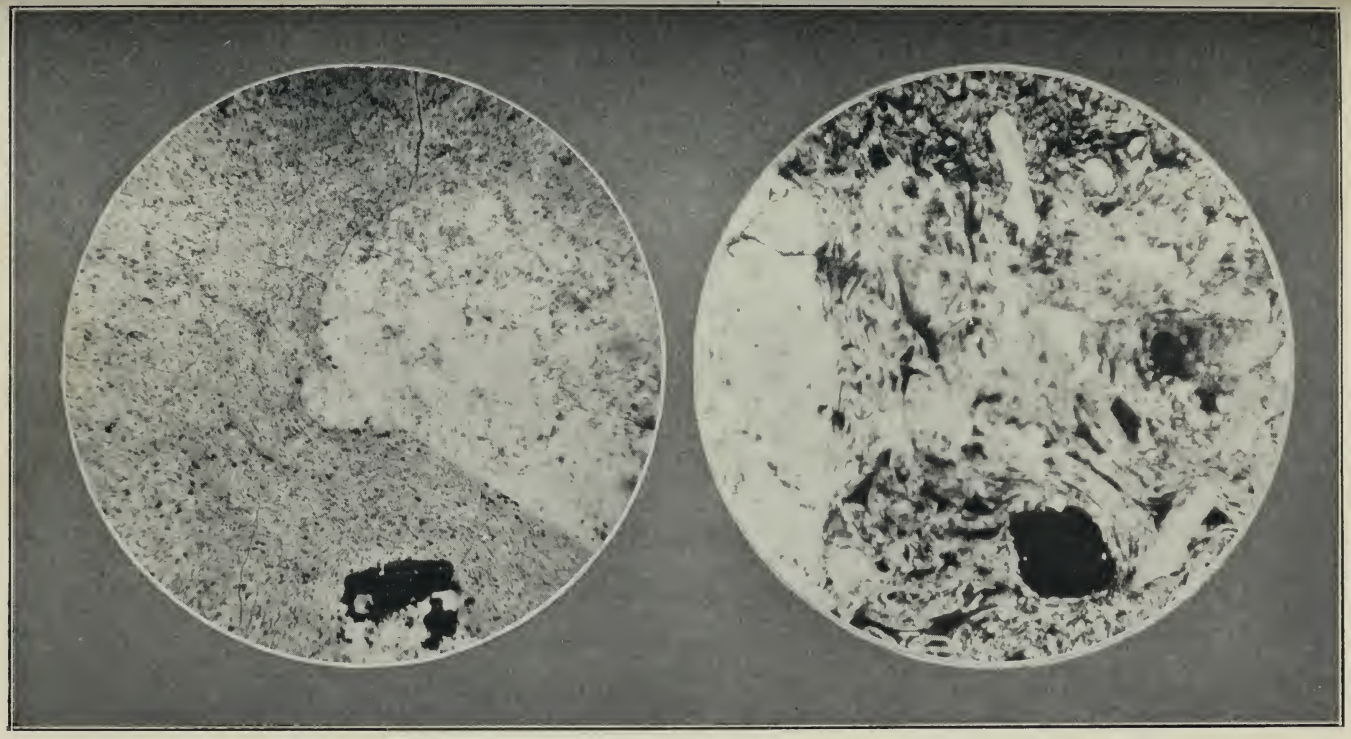
b *a*

ROCK SECTIONS.—Marshall.

PLATE XL.

a. Porphyry. Large crystal at bottom plagioclase. Rounded grains of magnetite. Smaller clear crystals and grains of orthoclase. Glassy base, showing damascened structure and flow structure. (C 286.)

b. Porphyrite. Large crystal at top of figure plagioclase. Irregular grains of magnetite. Groundmass consists of glassy matter containing minute ferritic microlites. (C 283.)



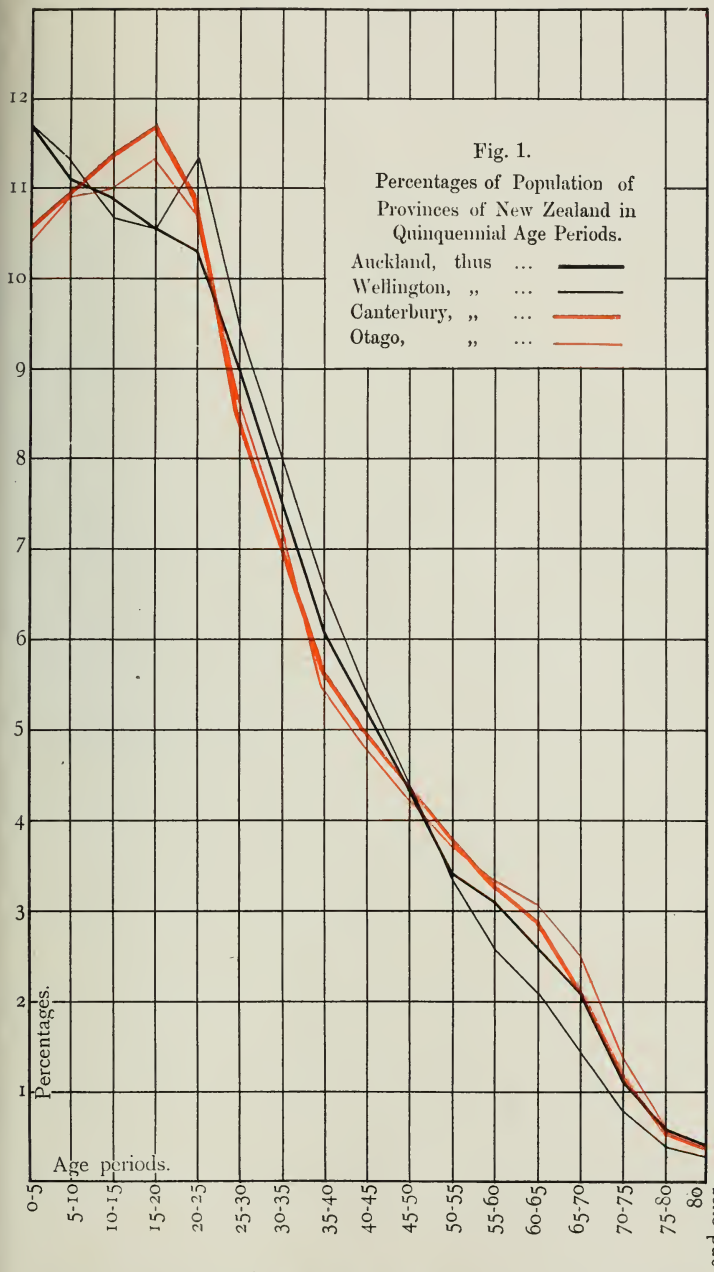
b *a*

ROCK SECTIONS.—Marshall.

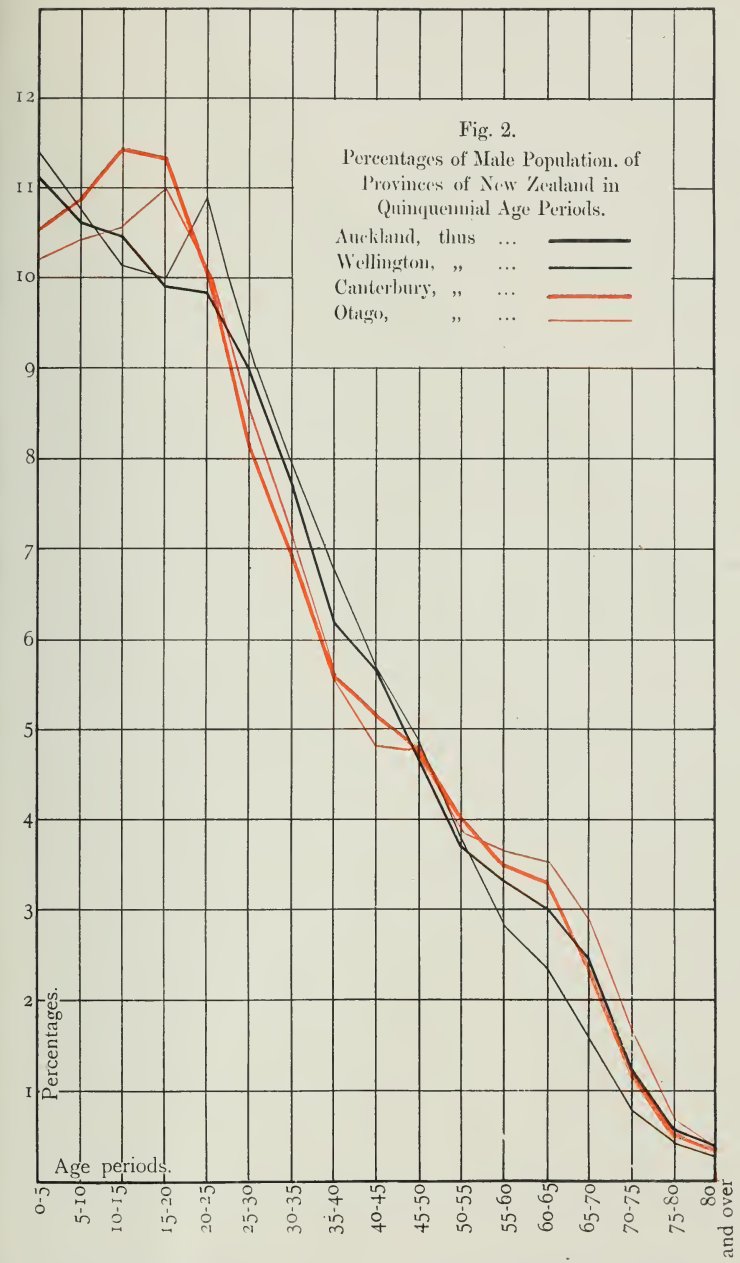
PLATE XLI.

Granite. Allotriomorphic grains of microperthite. Crossed nicols. (C 276.)

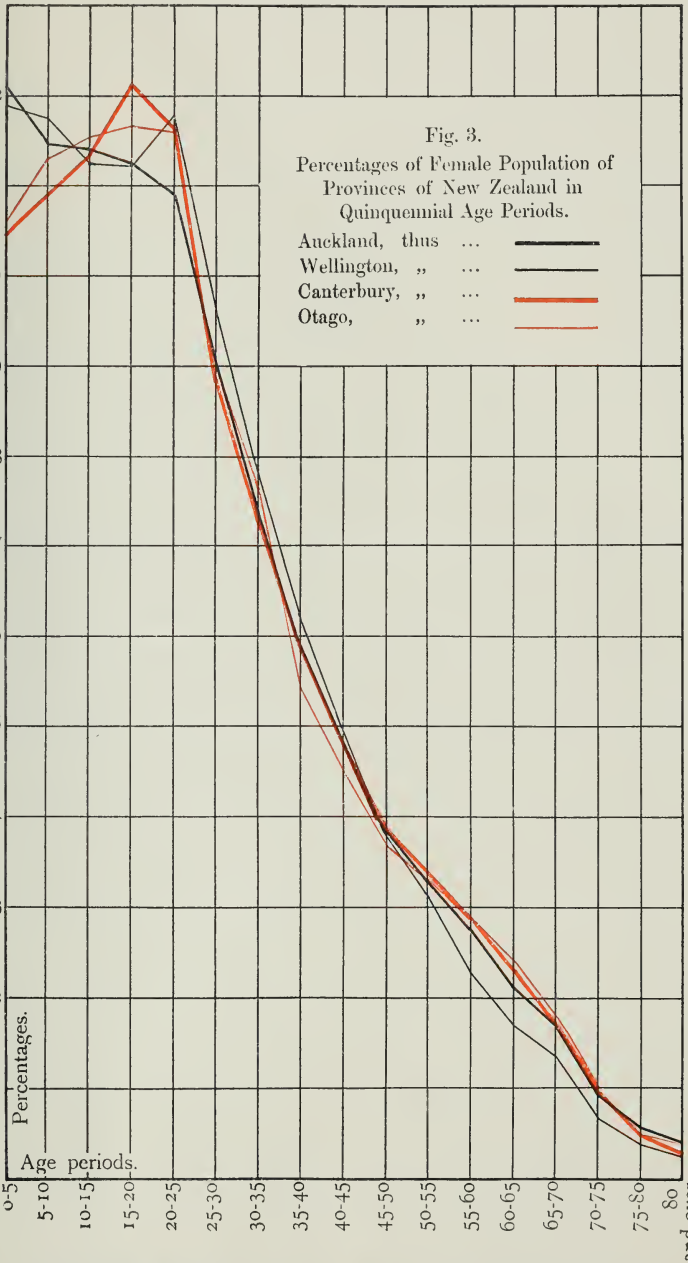
ROCK SECTION.—Marshall.



AGE-DISTRIBUTION IN NEW ZEALAND.—Segar.



AGE-DISTRIBUTION IN NEW ZEALAND.—Segar.



AGE-DISTRIBUTION IN NEW ZEALAND.—Segar.

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